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BERKELEY, CALIFORNIA

California
Reserve

AVOCADO CULTURE IN CALIFORNIA

PART I. History, Culture, Varieties, and Marketing
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PART II. Composition and Food Value
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REVISION BY R. W. HODGSON

BULLETIN 365

JUNE, 1923

REPRINTED DECEMBER, 1924

REVISED JUNE, 1928

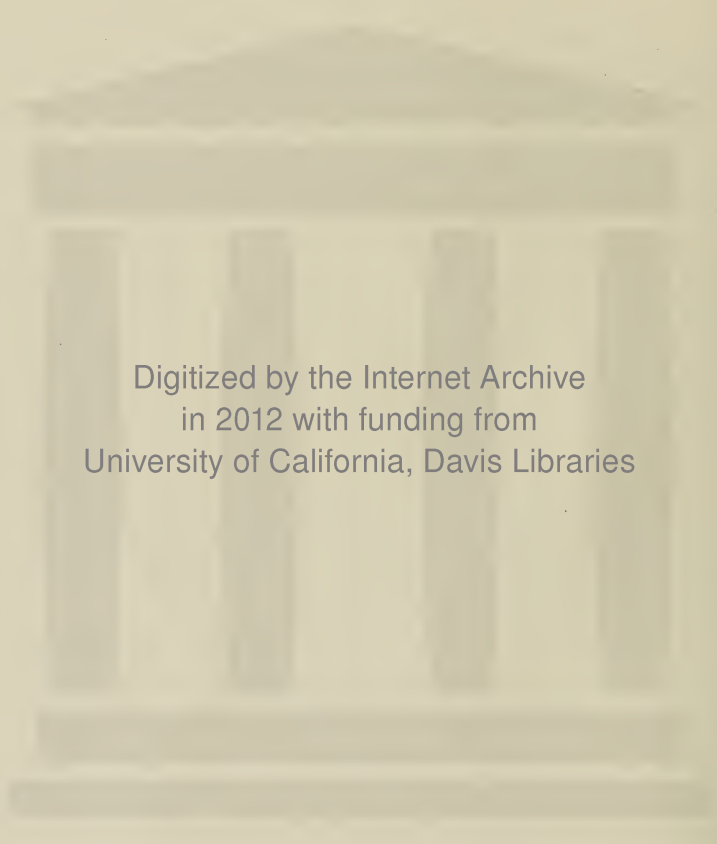
UNIVERSITY OF CALIFORNIA PRINTING OFFICE
BERKELEY, CALIFORNIA

1928

FOREWORD

The rapid growth of the avocado industry has been one of the notable developments in California horticulture during the past fifteen years. This period has witnessed a transition in the use of the avocado from that of a dooryard curiosity to a fruit supporting a well established commercial industry embracing approximately four thousand acres. The first publication on the avocado issued by the College of Agriculture appeared in 1915 in response to the need expressed at that time. The information then available was necessarily limited; the industry has made rapid strides since its publication; methods and practices have changed; and much new information has been developed. In order to meet the rapidly growing demand for the best information available Bulletin 365 was prepared and issued in 1923. This publication has now run through two issues and in order to bring it up to date has been completely revised in this printing. The material referring to methods, practices and varieties must be considered in relation to a young, rapidly-growing industry, which has been little investigated, hence the information furnished will be subject to further modification as progress is made.

ROBERT W. HODGSON,
Division of Subtropical Horticulture.



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HISTORY, CULTURE, VARIETIES, AND MARKETING

PART I

KNOWLES A. RYERSON

HISTORY

The first reference to the introduction of the avocado into California is made in the Report of the Visiting Committee of the California State Agricultural Society in 1856. According to this report Dr. Thomas J. White, living near San Gabriel, had imported the avocado from Nicaragua along with other tropical fruit plants. It was not until some years later that the avocado became definitely established through the introduction of three trees from Mexico in 1871 by Judge R. B. Ord of Santa Barbara. Two of the three trees of his importation for many years bore fruit in Santa Barbara and served to create interest in further plantings.

California has been fortunate in having had among her early settlers persons who have taken a keen interest in horticulture, especially that phase of it dealing with subtropical plants—fruit-bearing and ornamental. The early history of the avocado in this state is particularly marked by such effort. In the years following the introduction by Judge Ord, many trees were planted, some being imported from Mexico and the countries of Central America, others being started from the seeds of the many fruits that had found their way into California, brought here by travelers. Among the many who contributed much to the impetus given avocado growing were Mr. J. C. Harvey and Dr. F. Franceschi (Fenzi), formerly of Santa Barbara.

In the early nineties Mr. Juan Murrieta, becoming interested in the avocado through Mr. Harvey, imported a considerable quantity of thick skinned fruits from Atlixco, Mexico. Some seeds from these he distributed among his friends and others he planted. From this group of seedling trees have come a number of the varieties that first attracted attention, as promising commercial fruits, fifteen to eighteen years ago. These include the Royal, Walker, Challenge, Dickey, Blakeman, Sharpless, Colorado and Murrieta. Mr. C. P. Taft of Orange, in 1899 and the years immediately following, also planted many seeds from various sources. As a result of the showing made

by the fruits produced in the plantings mentioned, interest in the commercial possibilities of the avocado received a decided impetus in 1911 and 1912.

The period since, has been marked by special emphasis on the commercial aspects of avocado culture (fig. 1). In place of relying on chance seedlings, nurserymen began the exploration of the avocado districts of Mexico and Guatemala. F. O. Popenoe and T. U. Barber of the West India Gardens, Altadena, were pioneers in this field, and



Fig. 1.—Bearing avocado orchard in southern California.

during 1911–12 brought in buds from many varieties in the best districts of Mexico. Of these the Fuerte and Puebla have proved to be of especial merit. E. E. Knight of Yorba Linda, a resident for many years in Central America, brought in buds of superior varieties from Guatemala, of which the Queen and Linda are the most promising.

Mr. Joseph Sexton of Goleta, imported selected seed and buds from the best West Indian varieties grown in the Hawaiian Islands. The failure of his planting, under favorable climatic conditions, early indicated the futility of planting varieties of this race. Realizing, however, that private endeavor could not expect to cover completely the avocado districts of foreign countries, and that thorough investi-

gation should be made in such places if the industry was to start out with the advantage of the best varieties available as a foundation, the U. S. Department of Agriculture undertook the exploration of all avocado districts in Mexico and Central and South America. For the better part of nine years Dr. Wilson Popenoe, as an agricultural explorer, combed these regions, with the result that the avocado growers of California and of Florida now have the best that the world affords in the way of varieties upon which to build a commercial industry. Probably no other horticultural industry has had a similar advantage in its infancy. These introductions have now been under test for a number of years and some of them are showing decided promise in southern California. It will require several years more at least before their value and adaptation to conditions in this state will be determined.

The work of the California Avocado Association, which was organized in 1914, has been one of the important factors in the rapid development of avocado culture. Its Committee on Registration and Classification of Varieties has rendered particular service in studying varieties and recommending those suitable for commercial planting; its present list of a few standard varieties is an indication of the careful work which has characterized its activities. The published proceedings of this organization form the most valuable contribution to avocado literature available at the present time.

Fostered by the Association, a cooperating marketing agency, the California Avocado Growers' Exchange, was formed in 1924 and thus far it has functioned successfully in marketing the rapidly increasing crop. In 1927 the name was changed to Calavo Growers of California.

BOTANICAL DESCRIPTIONS AND RELATIONS

The avocado belongs to the genus *Persea*, a member of the Laurel family, to which belong also such economic plants as camphor, sassafras and cinnamon. The common native California bay tree is likewise a member of this family. The cultivated species of this genus are native to Mexico, Central and South America. Early classification of avocados cultivated in the United States placed all in one genus, *Persea americana* Mill. (*P. gratissima* Gaertn.) Later studies have revealed two distinct species, *P. americana* and *P. drymifolia*; the former includes all varieties horticulturally grouped in the West Indian and Guatemalan races; the latter includes the small fruited varieties of the Mexican highlands, of which many are grown in

California, and which have also spread to Ecuador, Chile, and to a limited extent to the regions bordering the Mediterranean. These are grouped into the so-called Mexican race.

Persea drymifolia can be distinguished from *P. americana* by the very pronounced anise odor that can be detected in the leaves and young growth of the former when crushed; this odor is entirely lacking in *P. americana*. The flowers of *P. drymifolia* are regularly more pubescent than those of *P. americana* and the under surface of the leaves more glaucous. The fruits of *P. drymifolia* are characterized by a thin, membranous skin, differentiating them markedly from those of *P. americana* which have a thick skin varying from a leathery to a brittle texture. The fruits of the latter species are usually much larger than those of the former. Both species are represented in the cultivated avocados of California.

The tree is evergreen, though in certain varieties practically all of the leaves drop for a brief period during the flowering season. The leaf blades are of many different shapes—oval, ovate, obovate, lanceolate, elliptic; and combinations of these appear. The leaf base is usually acute or truncate, the apex varies from almost blunt to acuminate. In length the leaves vary from 3 to 15 inches. The color of the mature foliage is usually bright green, the young growth, however, often exhibits varying shades of red and bronze. The manner of three growth is variable, the tall, upright, unbranched habit and the short, well-shaped, spreading habit are both commonly found. Seedling trees attaining an extreme height of from fifty to sixty feet have been noted where soil conditions are particularly favorable (fig. 2). Budding apparently has a dwarfing effect. The resulting trees are more compact and spreading, and seemingly not inclined to grow as high as seedlings. None are of sufficient age however to settle this definitely.

The small, pale, green or yellowish flowers are borne in terminal racemes. They possess both stamens and pistil. Differentiation between calyx and corolla does not occur in the avocado blossom. The petal-like structures are in reality perianth lobes, of about equal length, the inner series sometimes being longer than the outer. They are more or less pubescent, pronouncedly so in *Persea drymifolia* and sometimes almost glaucous in *P. americana*. The nine stamens are arranged in three series; the anthers are four-celled, the cells opening by valves hinged at the upper end. At the base of each stamen of the inner series are two large, orange colored glands which secrete nectar, presumably for the attraction of insects. Inside the stamens are three staminodia. The ovary is one-celled, and contains a single ovule. The



Fig. 2.—Mature seedling avocado tree indicating the height to which such trees grow in southern California. Note also the lath screen for wind protection.

style is slender, usually hairy, with a simple stigma. The flowers appear from November to May in California, varying according to variety and locality.

The fruit of the cultivated species is extremely variable in size, shape, color and other characters. Fruits of *Persea drymifolia* are found that are no larger than good sized olives, while the largest varieties of *P. americana* weigh over three pounds. In shape they may be round, oval, pyriform, "bottle necked," or any of the numerous gradations between these forms. The color ranges from light, yellowish green, through dark green, maroon, brown, reddish brown to purplish-black. The skin is thin and membranous in *P. drymifolia*, while in *P. americana* it is thick, tough, and even woody, or shell-like in some varieties, with an extreme thickness of a quarter of an inch. The fleshy, edible part, lying between the skin and the single large seed, is of a buttery consistency, creamy to bright yellow in color, often greenish near the skin. It contains a high percentage of oil. Streaks of fine fibers traverse the flesh from the stem to the base of the seed; these make up the vascular system, and are invisible in ripe fruits of many varieties. Each fruit contains a single, large seed, and the seeds of different varieties vary greatly in shape, being round, oblate, spherical, conical, or of slender form. The seed is inverted in the fruit so that the base is on the side away from the stem and is covered by two seed coats of varying thickness, often adhering closely to one another. The cotyledons are normally two, sometimes three in *P. drymifolia*, white or greenish white in color, and smooth or roughened on the surface. The seed is tight in the cavity in some varieties and loose in others.

AVOCADO DISTRICTS IN CALIFORNIA

The commercial avocado plantings of the state are located in climatically favored areas in southern California in two more or less clearly defined districts. The first is strictly coastal, embracing Ventura, Santa Barbara and parts of Orange, Los Angeles, and San Diego counties, and is subject to direct ocean influence. The second general district embraces the foothill slopes of the San Fernando, San Gabriel, and Santa Ana valleys, including Pasadena, Monrovia, Duarte, Uplands, Redlands, Riverside, and North Whittier Heights. In between these two general regions lie intermediate districts such as Fillmore, Hollywood, Whittier, and La Habra which partake of the characteristics of both. The plantings are for the most part con-

finer to the warmer parts of the citrus belt. Plantings in the Coachella and Imperial valleys have proved unsuccessful probably because of the extreme atmospheric dryness and the intense heat.

The avocado has been planted in central and northern California in many scattered localities. Trees are fruiting in Fresno, Tulare, Butte and other counties, and in sheltered locations in the San Francisco Bay region. They are for the most part Mexican seedlings and indicate that commercial varieties may be developed for these sections. Commercial plantings in these districts are still experimental.

California is justifiably noted for remarkable variation and diversity of climatic and soil conditions within relatively small areas. The success of a crop on a given site is therefore by no means a safe criterion on which to predict the success of the same crop on areas close by. This fact is especially important in its application to the selection of land for avocado plantings, on account of the extreme sensitiveness of this fruit to unfavorable environmental conditions. Thus, in the commercial areas above mentioned, by no means all of the land is adapted to avocado culture. In selecting a site for an avocado orchard it is, therefore, highly important that accurate information be obtained as to climatic and soil conditions. It is certain that many of the avocado plantings made in recent years are likely to prove unsuccessful on account of unfavorable environmental conditions. Information concerning climatic conditions, and particularly the frost hazard, may be obtained from representatives of the United States Weather Bureau. Data bearing on soil conditions are available in the various soil survey reports. Intending avocado planters are advised to consult the County Farm Advisor before selecting the site for the orchard.

CLIMATIC REQUIREMENTS

In general, the avocado is similar to the citrus fruits in its climatic requirements. The Mexican race can be grown where the orange thrives, while the more tender Guatemalan race is adapted to the milder districts best suited to lemon growing. Beyond a doubt the primary limiting factor of commercial avocado growing is the occurrence of low winter temperatures. The relative importance of this factor is directly dependent upon the degree and duration of such temperatures. Observations made following the cold waves of 1913, 1917, 1922 and 1925 have served to verify these conclusions. The

summary here quoted, made by Webber¹ following the winter of 1916-1917, gives in general the reactions of the tree to the different degrees of low temperature experienced:

- 30 deg. F.—Nothing injured so far as could be observed.
- 29 deg. F.—No injury of account; only traces on most tender growth of West Indian and Guatemalan varieties.
- 28 deg. F.—New foliage scorched on Guatemalan types; West Indian varieties showing considerable foliage damage.
- 27 deg. F.—Mexican varieties showed new tips slightly scorched; Guatemalans showed almost all new foliage injured; West Indians badly damaged.
- 25 to 26 deg. F.—Mexican varieties showed new foliage injured but some dormant trees uninjured; all Guatemalan sorts showed new foliage badly injured and some old foliage scorched.
- 24 deg. F.—Some dormant Mexican varieties uninjured; Guatemalan varieties badly injured, small limbs frozen back.
- 21 deg. F.—All Guatemalan types killed to bud; a few of the hardiest Mexican varieties, such as Knowles and San Sebastian, with young leaves only injured.

Exceptions occur due to peculiar local conditions, especially as they affect individual tree vigor. Varietal differences occur within the two races and will be mentioned later (fig. 3).

The avocado is also sensitive to hot summer temperatures. This factor is the main reason for its failure in the hot, dry, interior sections. Intense heat waves in the more favorable districts have caused serious damage in the past. Two varieties, the Caliente and the Tiger, have shown some promise of heat resistance in the more arid districts.

Atmospheric humidity is a factor of importance as evidenced by the behavior of the avocado in different parts of the state. The tree thrives best in the more humid coastal districts. Dry atmospheric conditions are detrimental as evidenced by the failure of trees to succeed in the Coachella and Imperial valleys.

Since avocado culture is carried on in California entirely under irrigation, the question of rainfall is not of importance except as it insures an adequate supply of irrigation water.

Wind has an important influence in avocado culture and is discussed in another section.

On account of the wide variation in climatic conditions within relatively small areas, previously alluded to, the greatest care should

¹ Webber, H. J. Cold resistance of the avocado. California Avocado Association Annual Report 1917: 49. 1918.

be exercised in the selection of a site for the avocado orchard. Not until all the information available has been obtained should a definite choice be made. If then it appears that the climatic conditions are suitable, choice of varieties should be made on the basis of both climatic and economic considerations (see section on varieties).



Fig. 3.—Relative frost resistance of seedling avocado trees of Guatemalan and Mexican origin. They were located in an exposed section of the San Gabriel Valley with no frost protection. Injury caused by cold wave of January, 1922.

SOILS

Observations on the behavior of the avocado in California indicate that it thrives on a wide range of soils. Commercial plantings are found on the very light, sandy soils and on the heavy black adobes and on the many different types between these two extremes. It seems to do best, however, on the medium-textured soils. For satisfactory results a depth of at least four feet is recommended. The avocado is extremely sensitive to poor drainage and will not endure a saturated soil for more than a few days.

In selecting the site for the avocado orchard the character of the subsoil should be most carefully determined. Structural faults such as clay layers, limestone, or hardpan close to the surface, are especially

unfavorable on account of the intolerance of the avocado to poor drainage. For this reason soils with these subsurface characteristics should be avoided.

California soils are notably variable in texture, structure, depth and other characteristics. While the soil survey reports are remarkably accurate and consequently exceedingly helpful, obviously they cannot picture in detail the local soil variability. This can only be determined by personal examination, by means of a soil auger or tube. Time spent in studying the soil conditions is unquestionably in most cases a profitable investment for the intending avocado planter. He will also usually find it advisable to consult the Farm Advisor in the county in which the land is situated.

PROPAGATION

Rootstocks.—Experience in handling and growing budded avocado trees during recent years has indicated the need for more information concerning the choice and selection of rootstocks. In the early years of the industry any kind of seed procurable was used to raise seedlings—West Indian, Guatemalan, or Mexican—large, small, mature and immature—with the result that many nursery trees failed to make a satisfactory growth, and many young orchard trees failed after planting. The West Indian seedlings were early discarded because of their tenderness to frost; and because of the more plentiful supply of seed of the Mexican varieties for some years most of the trees were propagated on this stock. In recent years, however, the situation has changed materially, in that seed of the Guatemalan varieties has been available in much larger quantities than is the case with varieties of the Mexican race. This, coupled with the fact that avocado seed cannot be brought in from Mexico on account of the avocado seed weevil, has resulted in many trees being propagated on the Guatemalan stock. While, in general, these trees appear to be satisfactory, the greater susceptibility of this stock to frost is a factor which should be given serious consideration in connection with its use. There can be little question but that the Mexican stock is the preferable one to use, on account of its greater resistance to frost.

The wide variation in Mexican seedlings, which has become especially evident in recent years, leads to the conclusion that many of the seeds represent natural hybrids resulting from cross pollination from nearby Guatemalan trees. It is possible, however, on the basis of the leaf and coloration characters exhibited by the seedlings, to

separate out many, if not most, of the hybrid seedlings; and a number of the nurserymen now follow this practice regularly. There is evidence indicating that seedling variation from this cause would be greatly minimized if seed were taken only from isolated trees or solid plantings of Mexican varieties where the opportunities for natural hybridization are remote.

On account of its remarkable vigor, large numbers of trees have been propagated in recent years on seedlings of the Fuerte variety, which seem to be fairly uniform and vigorous. Seed is generally obtained from dealers, of which there are several specializing in avocado seeds, or from the cooperative marketing agency. The seed should be from fully matured, well-developed and well-shaped fruit, rather than from under-sized and immature fruit.

Growing the Seedlings.—Several methods are used in starting the seeds, differing only in minor details. The seeds are usually planted in boxes or beds containing at least six inches of a mixture of loam and clear sand, a mixture of half of each being a common practice. The seeds are planted base downward with the apex barely protruding above the soil. Large beds are sometimes made either over a hotbed or in the open. Muslin or lath screens are placed over the beds during the hottest part of the day during hot weather. It was formerly a rather common method to plant the seeds in pots, but this practice has for the most part been discontinued. They are best planted as soon as possible after removal from the fruit, but may be kept several months if not permitted to dry out. Since most of the Mexican varieties ripen in late summer and fall, seed is usually planted during this time of the year. Growth starts in late winter or early spring, so that the seedlings are ready to be set out in March or April when they have attained a height of four to eight inches.

When danger of frost is over and the seedlings have reached the height mentioned, they are usually transplanted directly to the nursery rows, fourteen to eighteen inches apart in the row, and the rows forty inches to four feet apart. It is considered good practice to clip off about two-thirds of each expanded leaf at the time of transplanting. Irrigation should immediately follow planting to prevent drying out. If the weather is particularly warm, temporary protection from the sun is necessary and is usually provided by placing a shingle on the south side of each seedling. Some nurserymen have in the past planted the seedlings in four-inch pots, later setting them out in the field from the pots before or after budding. Because of danger of the curling of the roots at the bottom of the pot, which may result in permanent injury, this practice has been discontinued. It can be used

with safety where the seedlings are held only from three to four weeks before transplanting. Frequent watering is necessary until they become established, after which irrigation every two weeks should be sufficient excepting in extremely hot weather.

Budding.—The operation of budding is simple, but must be carried out with unusual care and attention in every detail to insure success. Most of the failures common to the beginner are directly traceable to the neglect of some detail. The selection of bud-wood must be made with unusual care and with a knowledge of the peculiarities of each variety.

Seedlings to be used for budding should be kept in a thrifty, growing condition. They may be budded any time during the season when the sap is flowing freely, after they have attained a diameter of one-half inch. Usually this occurs early in the spring, April and May being the usual months for the operation. For budding during these months, well matured wood from the previous season's growth may be used. After active growth has commenced, suitable buds are not available until the new growth has hardened, usually by the latter part of June. At this time budding can again be commenced and continued until late in the fall. A certain percentage of the buds inserted in the fall will push out and make some growth and will require extra protection during the winter. Only buds put in very late in the fall can be counted on to remain dormant until spring.

Ordinarily wood that is well matured with fairly plump buds, that is, not hard and yet does not snap on bending, furnishes the best material for buds (fig. 4). The Fuerte will give high percentage stands from young buds taken almost to the tip of young growth. Intimate knowledge of the peculiarities of each variety comes only with practice and observation.

Shield budding, such as is used in the propagation of citrus and deciduous fruits, is the common nursery practice. A "T" incision is made within two or three inches of the ground, preferably on the north side of the seedling. The bud is cut with a shield not less than an inch and a quarter in length, and is pushed gently into the incision. The stock should be in such condition of growth that the bark will slip readily, and will not require lifting by the knife blade, otherwise it is too dry to be used successfully.

The knife blade used for cutting buds should be thin and should be kept at a razor edge. The cut should be made parallel to the surface of the stick with a single, sliding motion; much of the success of budding depends on having the cut uniform, smooth and straight.



Fig. 4.—Desirable types of bud-wood used in the propagation of avocado trees.

After insertion, the bud is immediately wrapped, beginning at the top and working down. Various materials are used; raffia, cotton twine, rubber bands, muslin, and budding cloth, all are employed. Budding cloth is recommended, provided a hard wax is used in its manufacture which will not melt and injure the bud in hot weather. A wax composed of one pound of beeswax and one quarter of a pound of rosin is satisfactory. Cheap grades of muslin are made up into rolls six inches wide and one inch in diameter, and boiled in the wax for fifteen minutes.

About three weeks are required for the buds to unite with the stock, during which period they should be examined and the wraps loosened to prevent binding. The top should be pinched back at this time in order to start the bud into growth. From six to eight weeks after budding the wraps may be safely removed. After another month of growth the seedling should be cut back still further, leaving some foliage to take care of the sap flow. When the bud has made a growth of four to six inches it should be tied up to the stock with raffia; staking should be done when it has reached a height of sixteen to eighteen inches. The seedling top should not be cut off until the bud has grown at least two feet; this operation is best done when the top has become somewhat hardened. A sloping, smooth cut close to the bud union should be made and the wound painted over with grafting wax.

A novel adaptation of budding has been developed by A. R. Rideout, of Whittier, in an effort to obtain an earlier indication of the results of seed selection. Seeds are sprouted in the regular way. When the rootlets are about an inch long, one of the two halves of the seed is carefully removed without disturbing the developing plantlet. A sharp cut is made, beginning at the base of the tiny shoot and extending through to the root tip. The other half of the seed is sometimes cut away, leaving a small wedge-shaped portion to assist in forcing the rootlet into the incision, or it may be left on entirely. The sprouting seeds so prepared are then inserted in limbs of mature trees or on nursery stocks by means of long "T" incisions. The tip of the root is inserted at the intersection of the horizontal and vertical incisions and gently forced down in the same manner as in shield budding, until the split radical is well in place. Strips of specially prepared budding rubber an eighth of an inch in width are used to bind the sprouted embryo in place and a piece of dental rubber sheeting is wrapped over the area to prevent drying out and to exclude the entrance of water from without until union has taken place. By this method the seedling becomes a new branch on a mature

tree or the top of a young tree, and probably will come into fruiting considerably sooner than if grown as a seedling plant. The operation is not at all difficult and requires only care on the part of the operator.



Fig. 5.—Year-old budded nursery stock, balled ready for shipment.

Balling.—It is the customary practice to ball the trees prior to the starting of growth in the spring, and to hold them in the lath-house until planting time, although some nurserymen prefer to delay balling the trees until ten days or two weeks before they are to be

planted in the orchard. A few days before balling, the trees are cut back partially or partially defoliated, or both, to balance the loss of part of the root system. The cuts should be waxed to prevent excessive evaporation. A ball of earth ten to twelve inches in diameter and fourteen to eighteen inches in length is removed with each tree (fig. 5). The trees are then hardened off by storing under lath until planting time. Care must be taken to keep the balls moist.

Some experiments have been tried of planting budded avocados with bare roots, but these have not been very successful, and the practice cannot be recommended.

Nursery Tree Standards.—Until recently avocado trees were sold by height, a premium being paid for the tall trees. It became apparent some years ago, however, that the tall, slender trees frequently did not do as well in the orchard as the shorter and more bushy trees. They often failed to make much growth for several years, while the smaller trees generally started off immediately and within a year or two were ahead of the originally larger trees.

This experience has brought about a rather marked change in nursery practice in the past two years, and the majority of the trees are now sold by caliper, the measurement being taken one inch above the bud union. It has been found that if the trees are not forced to grow tall, but are permitted to assume a bushy habit, they are more stocky and do better when set out in the orchard. Such trees do not require expensive staking and protection from sunburn, though wind protection is necessary, regardless of the type of nursery tree.

At least one of the larger avocado nurseries now sells all trees on the basis of two grades, guaranteeing the buds to be from bearing trees of good yield record, and the stocks to be of pure Mexican parentage. The relatively high cost of nursery trees and of bringing an avocado orchard into bearing makes it especially important that only the best possible trees be used. Buds from record trees in fruit usually sell at from three to five cents each.

Topworking.—The occurrence of many unproductive trees and trees producing inferior types of fruit has created much interest in methods of working them over to desirable productive strains. Several successful methods have been developed; of these, budding and cleft grafting are the most generally used. In budding over large trees, buds are inserted directly into the old bark on the trunk or main limbs wherever possible in order to save time and to form the new top close to the head. Budding can be done only when the sap is flowing freely and the bark raises easily, usually from April to November.

From one-third to one-half of the top is first removed by a thinning-out pruning. The trunk and limbs exposed should be given a coat of whitewash to prevent sunburn. From two to four buds are inserted in each of the branches to be budded in such a manner that one wrapping suffices for all. One or two "safety" limbs are generally left to nourish the roots and take the surplus sap until the new head is established, after which they are removed.

Buds are taken from mature wood one-half to one inch in diameter. They are cut to a length of about two inches, the upper or lower end being cut off square to facilitate forcing the bud into the incision, according to whether the ordinary "T" or inverted "T" incision is used. Where the bark is very thick it is scraped as an aid to easy insertion. The wrapping commonly used is No. 16 white cotton string; it is wound tightly over the bud, leaving only the eye exposed. This wrapping should be left on for at least two months, since if cut earlier the bark on large trees has a tendency to lift away from the bud. Sucker growths are removed in order to start the buds into growth. The new buds are carefully tied to the limbs to prevent breaking. The budded limb should not be cut back until the new growth has become somewhat hardened and is able to take care of the sap flow; this operation is usually done the following season. It may be necessary to pinch back the bud-shoots to encourage early branching.

Considerable time can be saved if cleft-grafting is used instead of budding. The drawback to this method is the increased cost of scions. Fewer can be taken from any one tree because of the excessive amount of cutting back required to secure them. Where trees have well-formed heads consisting of two or three well-spaced framework limbs, a new head can be built by inserting two scions in each, eventually removing one of the scions if both take, leaving the more vigorous. Limbs not used for grafting are gradually removed as the new top develops and is able to take care of the entire sap flow. Very large trees with no branches close to the ground can be successfully reworked by cutting off the trunk at a height of about four feet and inserting at least four scions. Special precautions must be taken to keep large wounds well protected against the entrance of heart rot fungi by the use of waterproof paint or wax.

Avocado wood is unusually brittle and in sawing off limbs to be grafted the first cut should be made about a foot or more above the point where the scions are to be inserted. This is done to prevent splitting, and permits the second cut to be made clean and smooth. The scions should be of second growth wood, well matured, and should have two or three buds well placed, plump and well formed, but not

far advanced. It is especially desirable for the scion to include a growth made near the base so that advantage may be taken of the many adventitious buds arising in that zone. This insures growth, once union is effected. The scions are cut wedge-shaped, tapering for a distance of one and a half to two inches, depending somewhat upon the size of the wood used and the limbs to be grafted. The cuts are also tapered slightly from front to back, giving a very slight



Fig. 6.—Avocado tree topworked by cleft grafting. Note the nurse limbs left, whitewashed trunk and branches, and paper bag protectors.

wedge shape, enabling the scion to fit more closely into the cleft. Much of the success in topworking depends upon making the cuts smooth and even, and the knife used for this purpose should be kept at razor sharpness by means of frequent stropping.

The cleft is made with an ordinary butcher's cleaver, care being taken to split the limb some distance beyond that required by the length of the scions. This reduces the pressure exerted on them. The edges of the cleft should be trimmed smooth with a knife. A hardwood wedge is driven into the center of the cleft and the scions fitted

so that the cambium layer of the scion and that of the stock coincide as closely as possible throughout their entire length. The wedge is then removed and budding cloth strips half an inch in width are wrapped tightly around the end of the limb. Grafting wax is painted over the surface of the cuts and poured down into the cleft so as to fill it. The tops of the scions are tipped with wax. Where the bark is thick, necessitating the setting in of the scions, the space between the bark and the scions is also filled with wax before the budding



Fig. 7.—Bark grafted avocado limb. The cut surface should be well protected by a waterproof coating.

cloth wrapping is applied. The operation is completed by placing a paper bag over the end of the limb, cutting a small hole for ventilation. This is not removed until the scions have made a good start. The trunk and branches should be protected against sunburn, preferably by whitewashing (fig. 6).

Various sorts of grafting waxes and wound compounds are employed, one of the most common being a mixture of three parts of rosin and one of beeswax. In recent years a commercial preparation, which appears to be a water-asphaltum emulsion, has come into prominence and is now extensively used.

Recently a modification of the cleft-grafting method has been developed, which appears to be phenomenally successful. Instead of splitting the stubs after cutting off the branches, they are deeply

notched with a saw. Large scion wood is used, the scions usually being cut rather short, with one or two buds. These are cut so as to exactly fit the notches and are driven tightly in place. Then all cut surfaces are waxed and the sacks attached, the trunk and branches white-washed.

Cleft and notch grafting are successful only when the sap flow is slow and the bark does not slip. These methods are used most in January and February, though they are sometimes successful as late as March and April.



Fig. 8.—Side grafting of the avocado. This method can be used any time when the bark slips readily.

The follow-up work is of especial importance. Rewaxing is usually necessary to prevent drying out. Supports should be provided early to hold up the rapidly growing shoots. These are best supplied by tying two-inch pieces to the limbs on which the scions are located; this allows flexibility and at the same time sufficient rigidity to insure adequate support. These supports will need to be lengthened from time to time, even after the growth is six to eight feet high, until it is well hardened.

Cleft grafting methods have the advantage that in the event of failure of the scions the new shoots arising from the cut ends of the branches can be thinned and budded in the same manner as nursery

seedlings. They are usually large enough for budding by June or July. Bracing the young budded shoots is especially important the first season or two as they are very easily broken off.

Other methods of topworking which have been used with success are bark grafting and side grafting. In the former the limb or trunk is cut off square, and the incisions are made from this point downward for a distance of about two inches (fig. 7); in the latter the regular vertical "T" incision used in budding is made on the side of the limb or trunk (fig. 8). Cutting back is done after the scions have developed. The scions are selected from well matured wood and made with a long sloping cut on one side only. They are pushed down into the incision after the manner of budding. Tying, waxing and follow-up work are the same as for the other methods. These two types of grafting are best done in the active growing season during the summer months, as success depends on the easy lifting of the bark.

Seedlings and named varieties exhibit a wide variation in the ease with which they may be worked over to some other desired variety. The Taft seems particularly difficult to topwork by cleft grafting; some others behave in a similar manner. The congeniality between the tree to be topworked and the desired variety from which scions will be taken should be learned if possible before attempting the operation.

ORCHARD MANAGEMENT

Laying Out the Orchard.—Two general systems of planting are in use: the square system, adapted to the gently sloping and more level lands, and the system of terrace planting used on the steeper hill slopes. In the ordinary square system planting distances vary from 15 x 15 feet to 30 x 30 feet, according to variety. Some of the tall, upright-growing varieties are being set at the minimum distance given, while the Fuerte and similar strong growing varieties are being planted from 24 to 30 feet apart, with a preference for the latter distance. With certain varieties, under favorable conditions of soil and climate, this distance may have to be increased as more is learned about the growth of the budded avocado tree.

In recent years the development of hillside lands for avocado plantings has come into considerable prominence. On account of the protection from frost afforded by the elevation, extensive hillside plantings have been made, especially in the North Whittier Heights, La Habra and Whittier districts (fig. 9). This system is of course more expensive because of the greatly increased cost of laying out

the orchard and the higher costs of orchard management. The limit of the steepness of the slope beyond which it is not practicable to terrace is estimated to be about 30 degrees. The contour grade varies from 1 to 2½ per cent, according to the distance the irrigation water will have to flow. The width of the terraces varies from seven to sixteen feet, the latter distance being considered the better when the slope permits. With narrow terraces nearly all cultivation must be done by hand. The trees are planted two to five feet inside the edge of the terrace, the tendency at the present time being to plant them in far enough so that irrigation furrows may be run on both sides. The



Fig. 9.—Construction of terraces for an avocado orchard near La Habra, California. (Photo by Webber.)

cost of terracing hillside land varies from \$100 to \$150 per acre, according to the steepness of the slope and the character of the soil. Where possible, grading should be done so that winter rains can have the opportunity of settling the terraces and indicating any irregularities that may interfere with the flow of irrigation water. It is advisable to run water down each terrace as a final test before putting in the trees; changes in the terraces are difficult to make after planting has been done. The distance terraces are placed apart averages about thirty feet, varying according to the slope and contour of the hillside. They may be brought closer together or spread wider apart, necessitating the elimination of some of the planting, or the addition of short rows in between to insure filling the entire space. Special care is necessary during the rainy season to prevent excessive erosion. Adequate surface drainage must be provided. The control of weeds is

more difficult on terraced plantings, because of the banks between terraces which can not be handled by horse or tractor drawn implements. Trees are planted 15 to 40 feet apart on the terraces, according to variety.

On both terraced and level plantings considerable attention has been devoted to the interplanting of different varieties with the idea of removing some of the trees when they reach maturity. For this purpose varieties for interplanting should have either an upright,



Fig. 10.—The furrow system of irrigation is commonly used on terraces. The length of the furrows should not exceed three hundred feet.

slender habit of growth or early bearing qualities. Double-planting has much to commend it and will doubtless increase.

The practice of replacing diseased or decadent citrus trees by avocados is on the increase and bids fair to become an important method of establishing avocado orchards, especially in the old citrus districts. By this means some income from the citrus orchard is received while the avocado trees are coming into bearing. The leveling and irrigation system are provided for, and the citrus trees offer considerable protection to the young avocado trees. Thus far the avocado seems to be practically immune to the attacks of gophers. The method is being watched with interest.

There is at least one possible drawback to this practice. The pollination of those varieties, the blooming period of which coincides with that of citrus trees, would possibly suffer from the fact that bees seem to prefer citrus flowers. Placing additional hives in the orchard may overcome the difficulty. Definite information on this point is lacking.

Planting and Care of Young Trees.—It has been the experience in California that young avocado trees are much more tender than citrus trees, and hence require more care and attention, at least during the first few years. The usual methods of planting and caring for citrus trees have frequently resulted in serious losses in young avocado orchards. On the other hand, if properly planted and attended to, avocado trees grow rapidly and within a few years outdistance citrus trees of the same age.

It is almost the universal practice to ball avocado trees in the nursery, even though they may be grown for planting only a short distance away. This practice is unquestionably to be recommended, as the young nursery-grown trees are exceedingly tender and very easily injured by exposure or careless handling. Especial care must be exercised in handling the trees after they have been balled. They should never be picked up by the trunk or dropped to the ground even though the distance be short. The tearing away of the tender, fibrous roots and the breaking of the contact between roots and soil incident to such treatment are almost certain to delay the starting of growth until several months after planting, during which period sunburn is quite likely to occur.

In deep, fertile soils the digging of large holes is unnecessary, but in many soils experience has shown the advisability of digging large holes and filling in with top soil. On account of the extreme sensitiveness of the bark to sunburn the bud-unions should be faced toward the afternoon sun. The soil should be thoroughly firmed about the ball before irrigation, rather than settling the soil by running water in the partially filled holes. Placing manure or other fertilizers in the holes is not recommended as it is likely to result in injury to the young, tender roots. Pulling back the corners of the burlap coverings of the balls and covering them with soil at the time of planting is advisable as this permits better contact between the soil in the ball and that in which the trees are planted. The young trees should never lack for moisture; they should be irrigated immediately after planting and at frequent intervals thereafter until well established. The interval may then be lengthened to two or three weeks in accordance with soil and climatic conditions.

Protection against sunburn was of especial importance for the slender, upright nursery trees formerly used, as was also staking to prevent wind damage. With the more compact trees of the type now most commonly used these precautions are not necessary, though some type of wind shelter or screen is advisable in all regions of either occasional or prevailing winds.

Cultivation to prevent the soil becoming packed around the young trees, and to keep down weeds, is essential. The surface soil should be maintained in optimum condition to take water readily. Some growers have found it a good practice to make basins and mulch the surface around young trees with bean straw or alfalfa straw. This practice appears to be especially effective where the soil in the balls is heavier in texture than the soil in which the young tree is set.

Care of Mature Orchards.—Cultural operations in mature avocado orchards differ little if any from those practiced in citrus orchards. Spring plowing or disking and summer cultivation are usually practiced. Cultural operations should be designed primarily to maintain conditions favorable to the penetration of irrigation water. Weeds should be kept down. On terraced plantings, plowing one way in the spring is about all that can be done, and on narrow terraces is accomplished with difficulty, if at all. As the trees spread out and cover such terraces the point is reached when hand work alone must be relied on.

Since the avocado is by nature a shallow rooted tree, deep cultivation or abrupt changes in depth of plowing or cultivating, are likely to cause injury, which is often exhibited in an excessive shedding of the young fruits.

Irrigation.—In general the water requirement of avocado trees is similar to that of citrus trees. Both are native to regions of high rainfall which comes during the growing season. The root system of the avocado is also similar to that of the citrus trees, the feeding rootlets being fibrous and located for the most part in the upper four feet of soil. Hence irrigation practice with these fruits is similar in all important respects. Both require the presence of available moisture in the soil at all seasons of the year, and yet it is certain that, under many conditions at least, citrus and avocado trees have been severely injured by excessive irrigation even where soil drainage is good. This seems to have been brought about by attempts on the part of many growers to maintain the soil moisture at a relatively uniform point.

There is much reason for believing that citrus and avocado roots are most active when the soil moisture is at a point considerably

lower than the normal field capacity of the soils in which they are located. If this be true it is necessary then for the soil moisture to fluctuate from its normal moisture holding capacity to some point approaching the wilting coefficient. That permitting the soil to dry out appreciably between irrigations is definitely beneficial to the growth and fruitfulness of both avocado and citrus trees has been amply demonstrated in recent years; and that this practice, unless carried so far as to cause pronounced wilting, cannot result in injury from lack of moisture has been adequately established from experiments conducted in the California Agricultural Experiment Station² and elsewhere. Experiments have shown that the use of water by plants is independent of the amount in the soil so long as the moisture content is above the wilting point.

The amounts of water required by avocado trees vary greatly in different parts of the state, and depend mainly on the age of the trees and climatic conditions. In the hot interior regions good bearing trees require the equivalent of thirty-five to forty inches of rainfall, while in the coastal areas twenty-five to thirty inches appears to be sufficient. Since the rainfall in the avocado districts is in general less than the total requirement of the trees, and in addition comes altogether during the winter months, irrigation is required to make up the deficiency and to supply the needs of the trees during the dry growing season. This is usually accomplished by applying three or four acre inches³ of water at each irrigation. The interval of application should be determined by examination of the soil. The only satisfactory way to determine moisture conditions is to examine the soil to a depth of at least four feet. This can be done to best advantage in most soils with a soil auger, or post hole auger. This should be a regular orchard practice.

Methods of applying irrigation water to avocado orchards vary. The prevalent practice is the use of furrows; this method gives satisfaction where the slope is not too steep and the soil not so porous as to result in loss of moisture and plant food by excessive penetration. For terrace plantings (fig. 10), furrows should not exceed three hundred feet in length for ordinary conditions; furrows anywhere from three hundred to four hundred feet in length are most satisfactory. The use of cross furrows to supply water in the dry portions of the tree rows is recommended.

² Veihmeyer, F. J. Some factors affecting the irrigation requirements of deciduous orchards. California Agr. Exp. Sta. Hilgardia 2 (6): 125-291. 1927.

³ An acre inch is approximately equivalent to the flow of 1 miner's inch of water in 50 hours or, conversely, 50 miner's inches flowing for 1 hour on 1 acre.

The mulched-basin system has been tried with varying success. Poorly drained basins in heavy soils have been known to cause the death of trees from suffocation during the rainy season. Opinions differ in regard to the ultimate success of the mulched-basin system. Some growers have already discontinued its use, while others continue



Fig. 11.—Special equipment has been developed for irrigating hillside plantings. The distributor shown above is used where the pipeline passes down a ridge with the furrows sloping each way from it. It is jointed so that it can be raised vertically to be out of the way of cultural operations.

it in new plantings. It reduces the amount of cultivation, is conducive to the maintenance of favorable soil moisture and temperature conditions, and supplies organic matter to the soil—where sufficient mulching material is kept in the basins. However, the basins are rather costly to install on very steep slopes and are expensive to maintain.

On the lighter soils flooding is necessary to get the water evenly distributed over the entire area, since a sufficient head can not be maintained to carry the water down furrows.



Fig. 12.—The use of overhead systems of irrigation is increasing. The above illustrates one of several types. (From Agr. Ext. Cir. 4).

Much attention is being devoted to overhead sprinkling systems in avocado plantings, following the example of some of the citrus growers. This method appears to be decidedly promising (fig. 12). By means of this system the water is applied uniformly, furrowing out is not required, and once the water is turned on but little attention is needed. A modified sprinkler system has been tried under the trees, but is not so successful because the limbs usually have to be cut high to allow the spray to spread. This leaves the trunks less protected during cold weather and serious damage from freezing has resulted. The cost of installing the overhead system varies from \$100 to \$350 an acre, according to the type of equipment used.

The drip system has been used by some growers, but does not give an even distribution of moisture and cannot be depended upon to meet the requirements of the tree during the growing season.

As already mentioned, the question of drainage is of equal importance with irrigation. The avocado tree requires an abundance of water, but it must also have thorough drainage—both surface and subsoil. The tree is intolerant to standing water.

Fertilization.—Little is known concerning the fertilization of avocado orchards. Experience in both Florida and California has demonstrated a marked response to applications of nitrogenous fertilizers but so far as can be determined no carefully planned fertilizer experiments have ever been conducted on the avocado. The results of citrus fertilization studies afford the best information available at the present time and it is believed they are applicable to the avocado, at least to a considerable degree. Studies of the soils in the citrus districts of southern California have disclosed that they are for the most part relatively well supplied with potassium and phosphorus, two of the three elements most likely to be deficient. These two require only the presence of decaying organic matter to make them available. These soils are, however, prevailingly deficient in nitrogen and organic matter and these materials are applied to mature citrus orchards in large quantities as a demonstrated means of maintaining production.

The amounts of plant food elements removed from the soil by avocado trees are probably as large as those removed by citrus trees. The avocado fruit is high in mineral content and in protein, and it is not improbable that avocados remove more elements from the soil than a corresponding crop of citrus fruits. The entire question must be given thorough scientific investigation before any definite statements can be made. For mature bearing trees the use of two pounds of nitrogen per tree per year is a safe minimum; at least half of it should

be secured from organic sources, preferably bulky manures. No better general fertilizer can be recommended than good barnyard manure. Alfalfa hay and beanstraw are likewise very satisfactory materials when they can be secured at a reasonable price. These bulky materials are best turned under during the fall of the year. With citrus trees the use of a quickly available nitrogenous fertilizer, such as nitrate of lime, has proved of value in helping to set the crop when applied from four to six weeks in advance of the blossoming period. There is reason to believe that a similar practice is beneficial to the avocado.

The fertilization of young avocado trees offers a different problem from that of older trees. The excessive use of nitrogenous fertilizers seems to have caused many to delay coming into bearing. The incorporation of quantities of barnyard manure in the pits in which young trees are to be planted is not to be recommended except to a limited degree in very heavy, tight soils. In these cases the manure should be placed at the very bottom of the pit and mixed thoroughly with the soil. Young trees will make a better growth if top soil is used to fill in the holes and if the use of fertilizers is withheld until the trees have come into bearing. Exceptions are to be made, of course, in the case of very poor soils.

Cover crops have long been used successfully as a means of partially supplying the organic matter requirements of citrus trees, and are being used to some extent in avocado orchards. Winter cover crops—usually purple vetch (*Vicia atropurpurea*) or bitter clover (*Melilotus indica*) are generally used because of winter rainfall. Where irrigation water is plentiful and cheap during the summer months, sweet clover (*Melilotus alba*) may be grown to advantage. It is of particular value on heavy, tight soils, because of the action of its large, deep-growing roots in opening up the subsoil and supplying organic matter and better moisture penetration to the lower layers.

Pruning.—No systematic study has been made concerning the pruning of the avocado. However, observations which have been made over a period of some years relative to different practices used by growers, together with principles applicable to other evergreen fruit trees, point to some fairly clear generalizations. The avocado requires little or no pruning once its framework has been established. Some thinning from time to time will be advisable to permit sunlight to reach the inside foliage. In some strong growing varieties cross branches develop which, if allowed to remain, result in poorly formed tops and severe breakage. Stubbing back should be avoided, as the resulting crop of vigorous sprouts only complicates the problem.

Mechanically weak growth should also be removed early, in order to eliminate causes of breakage.

Little or no heading back should be given young trees. In cases where a head is not naturally formed low enough, cutting back may be necessary. Examination of the trunk of a young tree will reveal several cycles of growth, each terminated by a series of dormant buds. The cut should be made just above the strongest of these buds, which on starting usually make an upright growth. The practice of heading back to laterals with the hope of developing one of these into a head has not been successful. In some of the weaker growing types, shortening in to strong buds has been reported successful in strengthening the stock and framework of the trees while young. Heavy pruning of young trees greatly accentuates vegetative growth and delays the fruiting period. Observations by Bioletti indicate that better tree growth is obtained in young evergreen fruit trees where little or no pruning is given, as compared with trees more heavily pruned.

HARVESTING

With the varieties now grown in California, avocado fruits ripen every month in the year. Since the fruit will not soften on the tree and the external indications of maturity are often almost imperceptible, considerable difficulty is frequently experienced in determining the proper period for harvesting. With most of the dark colored varieties this is usually not especially difficult, for by the time the skin is fairly well colored the fruits are ordinarily in proper condition for picking. There are exceptions, however, even in the dark colored sorts. The difficulties are much greater with the green varieties, though it is usually possible for the experienced grower to detect slight changes in the color of the skin and stem as they approach maturity. The brightness of the skin color usually diminishes and a slight yellowish tint to both skin and stem often develops; there is, however, no safe and certain criterion of horticultural maturity except the laboratory determination for oil content.

The ripening seasons of the different varieties vary notably from season to season, and also differ widely in the different sections. The variation from season to season relates somewhat to weather conditions but is apparently affected even more by the setting period of the bloom, which is often distributed over three or four months. Variation in maturity in the different sections appears to be related to differences in the amounts of heat during the year. In general, the hotter, interior districts are the earliest to ripen the fruit and the cool

coastal areas, the latest, though differences in the period of setting sometimes more than offset the normal differences in season of maturity in the different regions.

In order to provide for uniformity in the maturity of the fruit at the time of harvesting and especially to prevent the sale of immature avocados, which practice had become a menace to the industry, the California avocado growers in 1925 succeeded in having a state maturity standard of eight per cent fat or oil content established. This action has been productive of very great benefit to the industry in that it has rather effectively eliminated immature fruit, mostly windfalls or stolen fruit, from the markets. It is quite generally felt that the standard is still too low for the Mexican and Guatemalan varieties, as is evident from the fact that the requirements for the best grades of fruit marketed by the Calavo Growers of California are considerably higher. As further information is developed concerning the normal range of fat content of the different varieties it may become desirable to raise the standard somewhat. The refractometer method of oil determination has been found to be relatively accurate, and this method is now used almost exclusively.

The fruits are clipped from the trees in the same manner as lemons, double cutting being employed to insure that the stem is cut flush with the base of the fruit. They should never be pulled from the trees as the removal of the pedicel or "button" with most varieties is almost certain to result in decay. On account of the greater tenderness of the fruit it must be handled most carefully. The use of small canvas picking bags or buckets is advised as a means of preventing bruising of the fruit.

FROST INJURY AND FROST PROTECTION

Owing to the newness of the industry, comparatively little is known relative to the treatment of frost injured trees. Varieties differ widely in the degree to which they withstand low temperatures. Following the severe cold weather of January, 1922, observations were made on the various degrees of injury. Many trees that lost all foliage but which did not suffer injury to the framework parts recovered in a remarkably short time. New leaves were put out and in some cases bloom, followed with a small set of fruit the same season. The spraying of defoliated trees with whitewash immediately following the freeze is thought to have prevented sunburn and aided in recovery. Pruning should be delayed until all dying back has ceased; cuts can then be made with certainty. The resulting vigorous shoots should

be thinned somewhat, in order to direct growth into a smaller number of well-spaced, strong growing limbs.

Because of the softness of the heartwood and the readiness with which it decays, large frost cracks and injured areas should be carefully cleaned, disinfected with mercuric chlorid (corrosive sublimate) solution of a strength of 1:1000, and painted over with a waterproof covering such as asphaltum roofing paint or a rather soft grafting wax. Special attention should be given such wounds, as decay sets in readily and spreads rapidly. Where large areas of bark and wood are killed, it is a question whether or not the resulting mechanical weakness can ever be overcome sufficiently to make a satisfactory tree.

Frost injury may be classified under three divisions: injury to the blossoms, injury to the fruit, and injury to the tree itself. The Mexican varieties bloom during the winter and are thus especially subject to frost injury with the resulting loss of the crop, even though the trees themselves may not suffer. The Guatemalan varieties, on account of their later blooming period are much less subject to loss of crop from frost injury. Because of its high oil content the avocado fruit does not readily freeze. Heavy losses have occurred, however, due to the freezing of the stems which causes the fruit to drop.

The development of varieties which bloom after the frost and mature their crops in eight to ten months will materially reduce losses. Several such new varieties are now under observation.

Frost injury to the tree itself may vary anywhere from the killing of the young, tender growth to the killing of the tree down to the ground. Aside from variety, the degree of injury depends largely upon the physiological condition of the tree. In general, trees maintained under optimum growing conditions enter the winter in the best condition to withstand cold. The maintenance of ample soil moisture is especially conducive to frost resistance. Trees weakened from insufficient moisture are invariably less resistant and suffer more. The practice of withholding water during the fall, supposedly to harden off the trees, cannot be recommended as a sound practice. Trees thus handled are ready to start into growth again at the first rain which may occur in the early winter, and are in susceptible condition for frost injury. The best recommendation that can be made is to maintain favorable soil moisture conditions throughout the growing season and until the beginning of the rainy season.

There is a pronounced difference in frost resistance among the three races of avocados. The West Indian race is much too tender for planting in California with the exception of a few favored localities, and even there has rarely produced satisfactory fruits,

Studies on the relative freezing points of the cell sap of the different races show that the sap of this race freezes at higher temperatures than do those of the Guatemalan and Mexican varieties. Of these, the Guatemalan is the more tender.⁴ Prior to the freeze of 1922 it was generally believed that the Guatemalan race was as hardy as the lemon, and the Mexican as frost resistant as the orange. It is evident from many observations made following this freeze, that the Guatemalan varieties must be considered for the most part somewhat more tender than the lemon. Mexican varieties, on the other hand, were observed in some localities to be less injured than neighboring orange trees, while in other localities somewhat more injured. Two varieties especially, proved to be outstandingly resistant and suffered little injury where they had been grown under good cultural conditions. These were the Puebla, a thin skinned Mexican fruit; and the Fuerte, a Guatemalan variety having a leathery skin and which is apparently a hybrid with a variety of Mexican origin.

The behavior of these and of varieties of the Mexican race in general throughout the entire state lends weight to the belief that varieties of the latter race will play an important part in the development of the commercial varieties. It is certain that they merit much more attention than has been accorded them in the past.

Seedlings of some of the Guatemalan trees now fruiting in southern California have shown a hardiness equal to that of the Fuerte, and may be of a similar hybrid origin. Several of these came through the freeze of 1922 unscathed and have commenced blooming at an early age. One, at least, has already produced superior fruit. These trees may furnish some new varieties better suited climatically to southern California.

In an industry that promises such favorable returns, frost protection is deserving of more attention than it has received. With the exception of higher hillside plantings most of the avocado orchards are subject to periodic freezing temperatures. The loss of the fruit is of less consequence than the injury to the trees. Adequate frost protection must be considered a necessary feature of orchard management. In a very limited way various methods of protection have been used including planting under lath, growing under tobacco cloth, and orchard heating. Of these, the latter alone has proved satisfactory. Heaters of large fuel capacity, sufficient to withstand several days of cold weather, will be necessary. A heater to each tree will doubtless prove advisable.

⁴ Harris, J. Arthur, and Wilson Popenoe. Freezing point lowering of the leaf sap of the horticultural types of *Persea americana*. Jour. Agr. Research 7: 261-268. 1916.

WIND DAMAGE

The avocado is subject to wind injury which is manifest in breakage of limbs, in blowing off of fruit, and—especially when hot, dry winds occur—in the burning up of young growth and the drying out of foliage. The fruit may be scarred even though not caused to fall; this materially reduces its saleability, though not always the quality.

Damage from wind prevalence may be reduced by the use of lath screens, which are, however, expensive. Windbreaks are a material aid in prevention of wind injury, but their use on small plantings cuts down the amount of available space for trees, and increases the amounts of water and fertilizer that must be applied to maintain the orchard. The injurious effects to the tree caused by excessive evaporation may be minimized by the maintenance of good moisture conditions in the soil at all times and the application of additional water during windy periods.

INSECT PESTS AND DISEASES

The avocado in California has been remarkably free from serious insect pests and, until quite recently, from important diseases. Apparently introduced free from these hindrances, it has required some years for insects and diseases already established in California to adapt themselves to a new host plant. From this point of view the insect and disease control problems may be expected to become increasingly important in the future.

Among the scale insects which occasionally infest the trees are the black scale, *Saissetia oleae* (Bernard), the citrus red scale, *Chrysomphalus aurantii* (Maskell), the Spanish red scale, *Chrysomphalus dictyospermi* (Morgan), and mealybugs, *Pseudococcus* spp. The usual control method employed for these pests is the use of oil sprays. The Spanish red scale frequently attacks young trees in the greenhouse but has not yet been found on trees in the field. Inasmuch as it is an important pest of avocados and citrus trees in other parts of the world, its introduction and spread should be carefully safeguarded. The control of mealybugs is dependent to a large degree on the control of the attending ants and the use of predacious and parasitic insect enemies.⁵

Of the other insects⁶ perhaps the most important are the bean thrips, *Heliothrips fasciatus* (Pergande), and the greenhouse thrips,

⁵ Borden, Arthur D. Control of the common mealybug on citrus in California. U. S. Dept. Agr. Farmers' Bul. 1309: 1-10. 1923.

⁶ Condit, I. J. Insect pests of the avocado. California State Comm. Hort. Monthly Bul. 8 (1): 27-29. 1919.

Heliothrips balmorrhoidalis (Bouche), which infest the fruit and foliage causing serious scarring, cracking and discoloration. They have been most injurious in the coastal areas, but also occur generally through the southern part of the state. Dusting with a 5 per cent nicotine dust will give control. The branch and twig borer, *Polycaon confertus* (Leconte), frequently bores smooth, round holes one-eighth inch in diameter and one-fourth to one-half inch long in the bud axils or in the forks of the branches. Sap collecting in the burrows, evaporates and produces white powdery masses over the entrance concealing them. This beetle occurs throughout the avocado growing districts of the state but is seldom sufficiently numerous to cause serious damage. The fruit-tree serica, *Serica alternata* (Leconte), has been responsible for the occasional defoliating of trees in Ventura County, but is not a common pest.

A number of fungus diseases of the avocado have been reported, two of which attack the trunk or roots, and several which affect the fruit. A root disease⁷ is caused by a species of *Pythiacystis*, similar to *P. citrophthera*, which causes a dying of the bark, indicated by black areas from which small beads of gum appear followed by the deposition on the surface of a white powdery substance. Conditions favorable for its development are excessive moisture and poor drainage, most commonly found in lath houses. The disease is not at all serious though occasionally large trees may be attacked. Dissecting out all affected tissue and disinfecting with bordeaux paste has proved a successful control measure. It was formerly believed that the avocado was immune to attacks of the oak root or toad-stool fungus, *Armillaria mellea*, but within the past five years a number of cases of this disease on the avocado have been reported. No entirely satisfactory treatment is known, although careful dissection out of all the diseased tissues followed by thorough disinfection appears to materially retard its development.

In recent years diseases affecting the fruit have increased greatly in seriousness and it is now apparent that unless control measures are developed for these diseases avocado growers must expect heavy losses in some seasons. Various fungi and at least one pathogenic bacterium, that producing citrus blast and black pit of the lemon, have been isolated from avocados decaying while still on the trees. The effect of some of these organisms appears to be confined to cracking and splitting of the skin, while others seem also to attack the flesh of the fruit. It is highly important that losses from these causes be pre-

⁷ Fawcett, H. S. A bark disease of avocado trees. California Avocado Association Annual Report 1916: 152. 1917.

vented insofar as it is possible to do so, but their prevention must await the results of investigations now under way. From a packing house point of view the worst of these diseases are anthracnose and a *Diplodia* spotting which sometimes pass through the packing house undetected, only to show up on arrival in the markets.

SOME FACTORS AFFECTING THE SETTING OF SATISFACTORY CROPS

Under apparently favorable environmental and cultural conditions, it is not uncommon for avocado trees to fail to bear satisfactory crops. This behavior is especially prevalent with the Guatemalan varieties in the interior districts where it often constitutes the principal deterrent to success. Even though bloom may be produced in abundance the young fruits very commonly fail to set, or in the event of setting, drop off before development proceeds very far. On the other hand, many seedling trees and some budded trees have failed to bloom regularly, even though well past the usual bearing age. Moreover, in most varieties there is a decided tendency to alternate bearing. The causes accounting for these unsatisfactory conditions are not well understood. There have been no long continued investigations with the avocado looking toward their solution; such investigations are greatly needed.

Pollination.—One of the factors that probably has much to do with the problem is that of pollination. Its importance in other fruit industries is well understood. The results of investigations in Florida by Nirody⁸ and in southern California and Florida by Stout⁹ of the New York Botanic Garden have given valuable information on the habits of avocado flowers. Present evidence indicates that:

1. Avocado flowers tend to open and close in unison and to open and close for two distinct periods at different times during the twenty-four hours.
2. The pistil is almost always receptive only during the first period of opening; during the second period the pollen is shed.
3. In most varieties there are few if any flowers open for the first time when flowers open for the second time are shedding pollen.

⁸ Nirody, B. S. Investigations in avocado breeding. California Avocado Association Annual Report 1922: 65-78. 1923.

⁹ Stout, A. B. A study in cross-pollination of avocados in southern California. California Avocado Association Annual Report 1922: 29-45. 1924. See also

Robinson, T. R., and E. M. Savage. Pollination of the avocado. U. S. Dept. Agr. Dept. Cir. 387: 1-16. 1926.

4. Varieties differ greatly in the length of time during which flowers are open, and in the time of day when flowers open both for the first and for the second time. Certain varieties are shedding pollen while others have pistils ready for pollination.
5. In a few varieties a considerable over-lapping between the two periods of opening occurs, making possible self-pollination.
6. Apparently, self-incompatability exists with a number of varieties, even when pollen is applied when the pistil is receptive; this renders cross-pollination necessary.
7. The state of the weather has a decided effect upon the time of opening, upon the period over which flowers remain open, and upon the time and manner of the shedding of pollen.

On the basis of their flower behavior Stout has classified all the varieties studied thus far into two general groups, those in which the flowers are open and the pistil receptive in the forenoon but pollen is not discharged (Group A), and those in which the situation is reversed in that the flowers are open and the pistil in receptive condition in the afternoon but pollen is not discharged (Group B). In both groups a second opening of the flowers occurs, at which time the pollen is shed. The intervening period of about twenty-four hours during which the flowers are closed separates the time of maturity of the sex organs in each flower.

GROUP A

Blakeman
Taft
Challenge
Dickenson
Colorado
Wagner
Murrieta Green
Grande
Sharpless
Taylor
Manik
Mayopan
Waldin
Collinson

GROUP B

Fuerte
Linda
Ganter
Lyon
Panchoy
Queen
Winslow
Winslowson
Pollock
Trapp

It appears probable, therefore, that more regular bearing of crops may result where plantings are made of varieties from the two groups, which should afford better opportunities for pollination than where varieties of only one group are planted. Since varietal compatibilities

have not yet been determined it appears desirable to use several varieties from each group, though observation has indicated that the Dickinson or Dutton and Fuerte are especially adapted to each other. It is to be hoped that self-compatible varieties may be found or developed, the opening periods of whose flowers over-lap. Such varieties would be ideal, at least from the point of view of pollination.

The bearing of crops by isolated trees in some localities and occasionally by solid blocks of well known varieties, where over-lapping does not ordinarily occur is not in conflict with the above observations. It has been pointed out by Stout that variable weather conditions, particularly abrupt changes in illumination, temperature, humidity and wind exposure caused marked changes in the rather precise periodicity of flower opening during clear, warm, bright weather. These changes result in increasing the amount and prolongation of over-lapping, frequently increasing the opportunity for self-pollination many fold. The more satisfactory setting of fruits of some varieties near the coast where atmospheric conditions are subject to both continual and frequent sudden changes is partially explained, in all probability, by this increased over-lapping. The unusually heavy crop on trees of almost all varieties in the 1923-4 season is also undoubtedly due in a large measure to the abnormal weather conditions obtaining throughout the blooming period in 1923.

Bud Selection.—It has long been known that the avocado is subject to bud variation. Black Ganter fruits are consistently produced on one limb of a large tree in Whittier. Round forms of the Fuerte have been discovered on standard trees. Such occurrences indicate the desirability of using care in the selection of bud wood. In the early days of the industry buds were taken from any kind of wood available and from any source convenient, with resulting wide variation in the type and quality of trees produced. At the present time nurserymen are giving very careful attention to the selection of wood from thrifty, good producing trees, and the type of nursery trees now being grown testifies to the value of this practice. Some work has been started along the lines of tree record keeping with the purpose of locating high producing parent trees. Such work will be handicapped until there is a sufficient number of trees growing under identical orchard conditions to eliminate environmental factors and make detection of inherent variations certain.

June Drop.—Severe shedding of the young fruits has been noted during hot weather and is not an uncommon cause of the low yields sometimes obtained. This trouble is especially severe in the navel

orange. Investigations by Coit and Hodgson¹⁰ have shown that it is ordinarily caused by the excessive evaporation that takes place from the leaf surface during periods of hot or dry atmospheric conditions. The root system is unable to supply moisture fast enough under such conditions and water is withdrawn from the young fruits to make up the deficiency, with the result that they are weakened and drop off. A spring cover crop, grown to furnish a good ground covering by June, has been found under certain conditions to cut down the temperature materially within the orchard and reduce the drop. Purple vetch planted early in March has given the best growth of any crop yet tried for this purpose. The extent to which this factor affects the avocado has not yet been determined, but in all probability it has an important bearing on the failure to secure satisfactory crops.

Rootstocks.—The importance of desirable rootstocks has already been mentioned. Sufficient attention to securing the most congenial stocks has not been given in the past. Certain varieties make very poor unions with stocks at present used and fail to make satisfactory trees. In this connection it is interesting to note a reaction observed in the W. A. Spinks orchard at Duarte. A number of large Harman trees were budded over to the Murrieta variety, and failing to make satisfactory growth, were topped and budded to another variety. Two or three of the Murrieta buds were overlooked and when the vigorous growing buds began to develop a thrifty top, the Murrieta buds were stimulated into active growth, put out strong branches, and have since borne good crops.

Studies with citrus and deciduous fruits have indicated the close relation to vigor and production that congeniality of stock and scion maintain. This phase of development of satisfactory yielding trees awaits thorough investigation.

Girdling.—Girdling has been resorted to as a means of stimulating fruit production on otherwise barren trees. Successful results have been obtained in some cases and in others none whatever. The Taft variety which has been conspicuous for its delay in coming into bearing has been the object of such experimentation more than any other. A number of growers have succeeded in getting fruit to set in abundance on girdled limbs while the rest of the tree failed to produce. Girdling is best done in October. A ring of bark varying from an eighth to a quarter of an inch in width is removed usually near the

¹⁰ Coit, J. Eliot, and Robert W. Hodgson. An investigation of the abnormal shedding of young fruits of the Washington navel orange. Univ. of California Publ. in Agr. Science 3: 283-368. 1919.

base of the limb; a ring of this size will readily heal over. Apparently the downward flow of sap is checked and the storage of food materials stimulates fruit production. Girdling is still largely in the experimental stage, however, and cannot be considered as the solution of the many-sided problem of rendering barren trees fruitful. It has the disadvantages of lowering the resistance to frost of the limb girdled, and of weakening the roots through subjecting them to a period of partial starvation.

MARKETING

Avocado production in California did not reach the point where marketing problems became acute until within the past three years. Prior to that time the production was relatively so small that the local markets were able to absorb the crop at very satisfactory prices. Price levels were in fact too high to favor any appreciable extension in the use of the fruit. These high prices, however, stimulated greatly the planting of avocado orchards to the extent that for some years past it has been evident that the time was not far removed when production would increase so greatly as to render it necessary for the growers to concern themselves with marketing problems.

In anticipation of this situation the California Avocado Association some years ago undertook a study of the marketing problem, with the result that in 1921 an arrangement was made whereby the fruit was marketed through a large fruit and vegetable marketing agency with selling agents in many of the principal markets. The crop was marketed on a commission basis, with the understanding that some effort would be made to introduce the fruit into new markets and to advertise it. The members reserved the right to market such fruit as they desired locally. This arrangement did not prove to be very satisfactory, and within a year or two the increase in production was such as to indicate the need for increased marketing facilities.

With the support and financial assistance of the California Avocado Association, the California Avocado Growers' Exchange, a cooperative marketing agency, was organized in February 1924. In 1927 the name of this organization was changed to the Calavo Growers of California. The plan of organization followed was similar in many respects to that employed by the citrus growers in that the organization is a non-stock, non-profit, cooperative agency, with a board of directors composed of elected representatives from the principal avocado producing districts and a limited number of directors elected

at large. A centrally owned and managed packing house was established at Los Angeles, and more recently several additional houses have been established at other central points.

Considering the problems presented in introducing and popularizing a new and unique fruit, and the limited funds which have been available, this organization has been remarkably successful in marketing the crops of its members. The percentage of the crop it handles has increased greatly since the time of its organization, and



Fig. 13.—The fruit is packed in excelsior in one and two-layer boxes for shipment. The above shows fruit as received from grower in lug boxes. Lower left, two-layer lug box packed and topped. Above it, one-layer crate holding one dozen fruits.

it is at the present time by all odds the dominant factor in the California avocado industry. It had scarcely been organized when the expected increase in production materialized and the necessity arose of immediately developing outlets for the fruit in the markets of eastern United States. This has required costly and sustained effort on the part of the producers, but it was indeed fortunate that the organization was available for the task. While, necessarily, progress has been slow, it has been able to extend the market outlets rapidly enough to absorb the surplus over the local requirements, which consist mainly of the markets in Los Angeles and San Francisco. As a

consequence price levels have continued to be high, much higher in fact than can probably be expected in the future when the production is several times what it is today.

Through the efforts of this marketing agency, many important improvements have been brought about in the industry, such as the adoption of a maturity standard, the enforcement of laws against fruit stealing, the initiation of much needed investigations, and others.

For the dual purpose of advertising California avocados and the brand of the marketing organization, the first grade, mature fruits of selected varieties sold by the Calavo Growers of California are stamped with the word Calavo, the term being derived from the abbreviation and combination of the two words California and avocado. Other grades have also been established, and in all cases the grade is stamped on the fruit. Each grade has certain requirements as to size, color, freedom from blemishes and fat content, the latter varying with the variety.

Official standard containers for avocados have not been adopted as yet, awaiting the results of experience in packing and marketing the fruit. On account of the susceptibility of the fruit to bruising, it is packed in wood or paper excelsior, and rarely or never more than two layers deep. The thirty-pound lug box packed with two layers of fruit is most commonly used, though several one-layer packs are also employed. All operations incident to the preparation of the fruit for market are performed by hand, which is necessary on account of the variation in shape of fruit in the different varieties and the marked susceptibility of the fruit to bruising. These operations include grading, sizing, weighing, stamping and packing. The fruit is packed unwrapped.

Avocados to be sold on the local markets are held in storage at room temperature until softened sufficiently for consumption within a few days. If storage for longer periods is required the fruit is held in cold storage chambers at 40 to 45 degrees Fahr., experience having shown that the fruit keeps best in this temperature range. Avocados have been successfully stored for more than two months. Fruit to be shipped to eastern markets is packed soon after receipt from the orchards and is held in storage in the markets until ready for consumption, unless it has softened sufficiently en route, in which case it is sold immediately.

In recent years shipment of the fruit to eastern markets, mainly Chicago and New York, has become of increasing importance as a means of relieving the local markets of surplus supplies, and the amount of the crop shipped out of the state has increased rapidly.

Whereas, a few years ago only a few hundred boxes of fruit were shipped to eastern markets, in 1927 of approximately one million pounds of fruit handled by the Calavo Growers of California, nearly two-thirds was shipped out of the state.

Most of the shipments in the past have been by express, though experience in the past year or two has shown that if properly handled the fruit stands up satisfactorily under fast freight. Carlot shipments have been made on a number of occasions during the past two years. It is expected that in the future mixed car shipments will play an important part in the distribution of the avocado crop. Experimental shipments by steamboat via the Panama Canal to New York have shown that the fruit successfully withstands the long trip, providing it is properly selected and prepared for shipment.

California grown avocados must meet the competition of Florida and West Indian fruits, which ripen during the summer and fall months, when there is an abundance of other fruits of other kinds; accordingly the price is lower than at any other time of the year. The best market is to be had during the winter months, and it is this market that is of particular interest to the California grower, as he already has varieties that mature at this season. With the establishment of the avocado as an important article of food rather than a luxury, an all-year-round demand will be created. Future commercial production must take this condition into account. At the present time there is sufficient variation in season among the varieties in California to furnish ripe avocados for every month of the year. It would seem desirable, however, for the growers in the various avocado producing sections to take advantage of the natural ripening seasons in their respective districts in so far as this is practicable. Thus, it would seem best for the growers in the early ripening districts to grow largely the early ripening varieties and for the growers in the late sections to concentrate mainly on the late varieties. For, obviously, an early ripening variety grown in a late district is neither early nor late and consequently cannot possibly command any premium on this basis. There may be other factors of sufficient importance to warrant the growers in some sections ignoring the above mentioned considerations, but in general it is believed they should be adhered to.

The place of the thin-skinned Mexican fruit on the commercial market has been more or less problematical. The fruit is finer in flavor, and often in quality, than many of the larger Guatemalan fruits. It comes on the market at a good time of the year and can be shipped very satisfactorily if given a little extra care. Objections to the small size of most varieties of this group can be overcome by

the introduction of large-sized varieties known to exist elsewhere (fig. 14). Some of these are now under trial. For local markets and for home use they have a very definite place. No general prediction can be made as to their future commercially, until the market has been exploited and the tastes of consumers determined.



Fig. 14.—Tamayo avocado (S. P. I. 54270). A large-fruited, thin-skinned variety of the Mexican race discovered by Wilson Popenoe in the Chota Valley, Ecuador. The fruits weigh as high as 18 ounces.

The discovery of these large-fruited varieties in Ecuador is of particular promise for the expansion of the area in California in which the avocado may become commercially profitable. (Photo by Popenoe.)

Marketing experience indicates thus far that in general there is a preference for medium sized fruits, weighing from eight to fourteen ounces, although there is a limited demand for the large fruited varieties. Color appears to be less important than size though the green fruited varieties seem to be more in demand than the colored sorts. The Mexican varieties have not met with favor in the eastern markets though they sell well locally and in some of the southwestern states. Of all the varieties shipped in quantity to the eastern markets the Fuerte and Taft have consistently met with the best reception.

The subject of varieties will be discussed in detail in another section, but it should be mentioned here that adherence to a relatively small number of standard varieties is of importance to the development of satisfactory markets. The work of the Committee for the Registration and Classification of Varieties of the California Avocado Association has already resulted in considerable progress in this direction.

RACES AND VARIETIES

As previously indicated there are three general groups of avocados grown in the United States, for convenience loosely termed the West Indian, Guatemalan, and Mexican races, though not strictly separate horticultural races in the technical sense of the term. Of these three races, two only are of commercial importance in California—the Mexican and the Guatemalan. Popenoe¹¹ has classified these groups as follows:

1. Leaves anise-scented; skin of fruit thin (rarely more than $\frac{1}{32}$ inch in thickness). *Persea drymifolia*. MEXICAN RACE.

2. Leaves not anise-scented; skin of fruit thicker (from $\frac{1}{32}$ to $\frac{1}{4}$ inch in thickness). *Persea americana*.

(a) Fruit summer and fall ripening; skin usually not more than $\frac{1}{16}$ inch thick, leathery in texture. WEST INDIAN RACE.

(b) Fruit winter and spring ripening; skin $\frac{1}{16}$ to $\frac{1}{4}$ inch thick, woody in texture. GUATEMALAN RACE.

At least one variety intermediate in form between the Guatemalan and Mexican races has appeared—the Fuerte, an apparent hybrid between these two groups. Other intermediate forms found in Central America and Mexico are at the present time unclassified.

The West Indian race is unsuited climatically to California conditions, as evidenced by the failure of the plantings tried in the past,

¹¹ Popenoe, Wilson. Manual of tropical and subtropical fruits, p. 66. The Macmillan Co., New York. 1920.

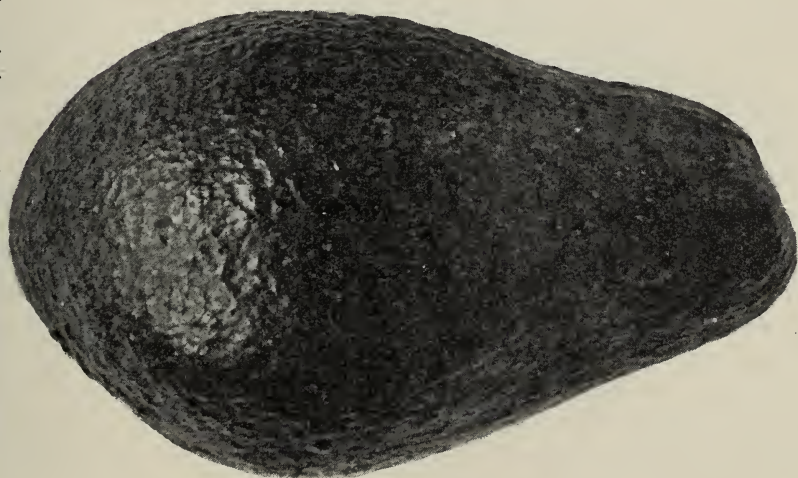


Fig. 15.—Fuerte, one of the most highly recommended varieties. Fruit green, with leathery skin, maturing from November to June. Two-thirds natural size.

and may be disregarded as far as its economic importance in this state is concerned. Belonging as they do to two different species, the important, outwardly-evident, botanical differences serve to differentiate the Guatemalan and Mexican races horticulturally. The leaves of the Mexican race are usually smaller than those of the Guatemalan, and are sharper at the apex. They have the characteristic anise odor when crushed which is entirely lacking in the Guatemalan race. This property is also characteristic of the immature Mexican fruits. The fruits of the Mexican race are smaller, rarely reaching a pound in weight, are smooth, dark green to purple in color, and often glossy. They mature usually from August to December from nine to ten months after blooming. The seed is commonly larger in proportion to the edible part of the fruit than that of the Guatemalan. The two seed coats are thin, sometimes closely united and adhering to the cotyledons, and sometimes separating. The flowers appear during the winter and early spring, and are subject to frost injury in severe winters. Occasionally late flowers appear and furnish a light second crop in the early spring.

The fruit of the Guatemalan race is large, averaging from 12 to 20 ounces, some varieties attaining a weight of more than three pounds. It varies in color from green to purplish or reddish black. The surface while sometimes fairly smooth, is usually rough and somewhat warty and coarsely granular in texture. The seed fits tightly into the cavity, its seed coats are thin, united, and adherent to the cotyledons throughout. The flowers appear later than those of the Mexican race, usually after most danger from frost is past. The fruit matures from twelve to eighteen months after the blossoming season.

Many varieties of both the Guatemalan and the Mexican groups are fruiting in California at the present time—the number exceeds two hundred. Because of their greater resistance to cold, the Mexican varieties enjoy a much wider range of planting. In choosing varieties for commercial planting certain general characteristics are to be desired in both the tree and the fruit. The tree itself must be adapted to the location selected. It should be a hardy and vigorous grower, forming a well balanced head capable of carrying good sized crops without breakage. It should be readily propagated and easily handled in the nursery. It should produce sufficiently good crops consistently, to be commercially profitable, and should come into bearing at a reasonably early date. Varieties that have come into bearing at too early a period, however, have a tendency to expend their energies in flowering and premature production at the expense of tree development. The first few years of the life of any fruit tree should be

Fig. 16.—Puebla, a deep maroon purple colored fruit with smooth, thin skin. Season, December to February. Natural size.



primarily devoted to the building up of a strong tree capable of sustained production over a long period of years rather than to the early production of fruit.

The length of time between blooming period and maturity is also an important consideration. Most of the thin-skinned fruits mature from nine to twelve months after blooming; on the other hand few of the Guatemalans mature under fourteen months, several requiring eighteen. Two of the newer Guatemalan varieties—the Ward and the Dorothea—bloom in the spring and mature their fruit in the fall and winter of the same year. In developing new varieties this question is one that should receive consideration.

Many varieties now fruiting in southern California have been noted to have a more or less pronounced habit of alternate bearing. Popenoe reports this condition quite general among the avocados in Guatemala. Thinning of fruit during the heavy producing years may aid in maintaining a more uniform annual production. No experiments have been conducted with the fruit along this line.

The market demands are important in considering the fruit itself. A medium-sized fruit, attractive in color, uniform in shape and readily packed, of good quality and pleasing flavor, fits the market requirements at the present time. The seed should not be large and should preferably be tight in the cavity. To meet the highest prices the fruit should mature during the winter and early spring months; at this season of the year less competition is met with other kinds of fruits and with avocados imported from the West Indies.

The matter of selecting varieties is one of considerable perplexity. The industry has been fortunate in its early history, in having an active growers' organization, the California Avocado Association, working in its interests. The Association early organized a Committee for the Registration and Classification of Varieties, whose duty it has been to study the behavior of the different varieties over a period of years and to make recommendations according to its observations. The lists of recommended varieties prepared by this committee afford the safest guide to planting at the present time. That these lists will be revised from time to time is certain; numerous changes have been made in the past as knowledge has been gained by experience. The commercial varieties of the future may be largely different from those of the present. The recommendations offered represent the concensus of opinion of the best growers at the present time.

The history of avocado culture in California has been an almost continual procession of new varieties as seedlings or introduced



Fig. 17.—Queen, one of the best of the large-fruited Guatemalan varieties. Color, purple. Season, May to October.

varieties have come into bearing and have been ardently promoted by their enthusiastic developers or introducers. Many varieties have been propagated and distributed prematurely. Others have been unwisely exploited before testing. The result is that there are many named varieties which have already been discarded and many more which should and will be abandoned in the future.

Descriptions of the principal commercial varieties and of the most promising of the not yet proven varieties are given below. Allowance should be made for normal variation in the size of the fruit and in the ripening season which differs markedly in different sections.

RECOMMENDED COMMERCIAL VARIETIES

Fuerte (fig. 15).—At the present time only one variety is considered worthy of unqualified recommendation for commercial planting. Form pyriform (not necked) to oblong; size below medium to above medium; weight 10 to 16 ounces, length 4 to $4\frac{1}{2}$ inches, greatest breadth $2\frac{1}{2}$ to $2\frac{7}{8}$ inches; base pointed; the stem inserted obliquely in a small shallow cavity; apex obliquely flattened, depressed around the stigmatic point; surface pebbled, sometimes slightly wrinkled around the stem, dull green, with numerous small yellow dots; skin about $\frac{1}{24}$ inch thick, separating readily from the flesh, pliable and leathery in texture; flesh rich cream yellow in color, greenish near the skin, of smooth, buttery texture, and very rich flavor; quality excellent; seed medium, tight in cavity, seed coats closely surrounding cotyledons. Season November to June in southern California. (Popenoe.)

Originated at Atlixco, state of Puebla, Mexico; introduced into California in 1911. The tree is unusually vigorous, hardy and productive. Its season of ripening is exceptionally long. The fruit contains 30% of oil, is of fine flavor and quality. This variety and the Puebla described below, were the two outstandingly hardy varieties on the recommended list of the Avocado Association that emerged from the severe cold wave of 1922 with comparatively little injury. The *Fuerte* is apparently a natural hybrid between the Guatemalan and Mexican races, though final proof of this assumption is yet to be made. It partakes of the characteristics of both races.



Fig. 18.—Nabal, one of the most promising of the U. S. Department of Agriculture introductions. Color, green. Season, May to July.

VARIETIES OF MERIT, CANDIDATES FOR COMMERCIAL RATING

Puebla (fig. 16).—Form obovoid, slightly oblique; size below medium to medium, weight 8 to 10 ounces, length $3\frac{1}{2}$ inches, greatest breadth $2\frac{7}{8}$ inches; base obliquely flattened, the stem inserted slightly to one side in a small shallow cavity; apex obliquely flattened but not prominently so; surface smooth, glossy, deep maroon-purple in color, with numerous reddish dots; skin less than $\frac{1}{32}$ inch thick, easily peeled from the flesh, firm in texture; flesh rich cream yellow near the seed, changing to pale green near the skin, buttery in texture, and of rich nutty flavor; quality very good, seed medium to large, tight in the cavity, with both seed coats adhering closely to the cotyledons. Season December to February in southern California. (Popenoe.)

Originated at Atlixco, state of Puebla, Mexico; introduced and first propagated in California in 1911. The tree is exceptionally hardy and vigorous, and well balanced in form. It fruits later in the season than most others of the Mexican race. Oil content 26.45%. Mexican race.

Queen (fig. 17).—Fruit, oblong-pyriform, large, $5\frac{1}{2}$ inches long, weighing $1\frac{1}{2}$ pounds; skin rough, deep purple in color, thick and woody; flesh rich clear yellow, dark green near skin, free from fiber; flavor rich, quality very good; seed very small and tight in cavity. Season May to October.

The variety was imported by E. E. Knight from the highlands of Guatemala. It is a vigorous but spreading grower, rather tender, and should be planted only in the warmest sections. The tree bears very good crops. Guatemalan race.

Taft.—Fruit pyriform in shape; size medium, weight 14 to 24 ounces; skin medium in thickness, slightly rough, green. Seed medium. Flesh cream to golden yellow, flavor rich, quality excellent. Fiber very slight.

Originated on place of C. P. Taft, Orange, Calif., in 1900.

Tree vigorous but usually slow to come into bearing; this is the chief objection to this variety. Especially adapted to the coastal districts. Season, May to November. Guatemalan race.

Nabal (fig. 18).—Number 15 of the U. S. Dept. of Agriculture introductions by Popenoe in 1917 from Antigua, Guatemala (S. P. I. No. 44439). Fruit almost round, weight 16 to 20 ounces. Smooth, green. Seed rather small. Flavor exceptionally good and quality excellent. A good grower and heavy and consistent bearer. Season, May to July. This variety is undoubtedly one of the most promising of the Department of Agriculture introductions. Guatemalan race.



Fig. 19.—Anaheim, a promising variety. Color, green. Season, June to September.

VARIETIES SUGGESTED FOR AMATEUR COLLECTIONS AND EXPERIMENTAL PLANTINGS

Varieties marked with the asterisk (*) are especially recommended.

Anaheim (fig. 19.)—Originated on place of E. C. Dutton, West Anaheim. Tree tall and slender. Fruit elliptical; 18 to 24 ounces, rough, green, glassy. Seed medium to small. Season, June to September. Guatemalan race.

Benik.*—Introduced by Popenoe from Antigua, Guatemala as No. 21 in 1917 (S. P. I. No. 44626). Fruit pear-shaped; 20 ounces, rough, maroon-purple. Seed small. Season, May to August. Guatemalan.

Caliente.—Introduced from Mexico by M. Garcia of Duarte, California. Fruit long-pyriform, necked; 5 to 10 ounces, smooth, glassy, deep mahogany-red. Seed medium. Season, October to December. Mexican.

Cantel.—Another of the Popenoe introductions from Antigua. Number 28 (S. P. I. No. 44783). Fruit round, 16 ounces, surface pebbled, green. Seed very small. Season, August and September. Guatemalan.

Carlsbad.*—Probably identical to the old Stephens No. 2 at Montebello. Fruit pyriform, 16 ounces, smooth, mahogany-purple. Flavor very good. Prolific. Seed rather large. Season, March to May. Guatemalan.

Colorado.—Sometimes known as Purple Murrieta. Originated at Los Angeles about 1901. Fruit oval, 14 to 18 ounces, slightly rough, purple with brown spots. Seed medium. April to August. Hard to propagate but top-works well. Guatemalan.

Dickinson (fig. 20).*—Originated in Los Angeles about 1899. Fruit oval to almost pyriform, 9 to 14 ounces, very rough, dark purple. May to October. Guatemalan.

Dorothea.—A seedling from the Miller tree at Hollywood. Fruit obovate, 8 to 12 ounces, smooth, light green. Seed medium to large. Season, November to February. Thought to be a Guatemalan-Mexican hybrid.

Duke.*—Originated at Sunnyslope nursery near Wyandotte, California, in 1912. Fruit pyriform, 8 to 12 ounces, green. Seed generally tight in cavity. Season, October and November. Mexican.

Dutton.—Originated at Anaheim in 1910. Fruit pyriform, 16 ounces, very rough, warty, dark maroon. Seed medium to small. Season, February to April. Guatemalan.

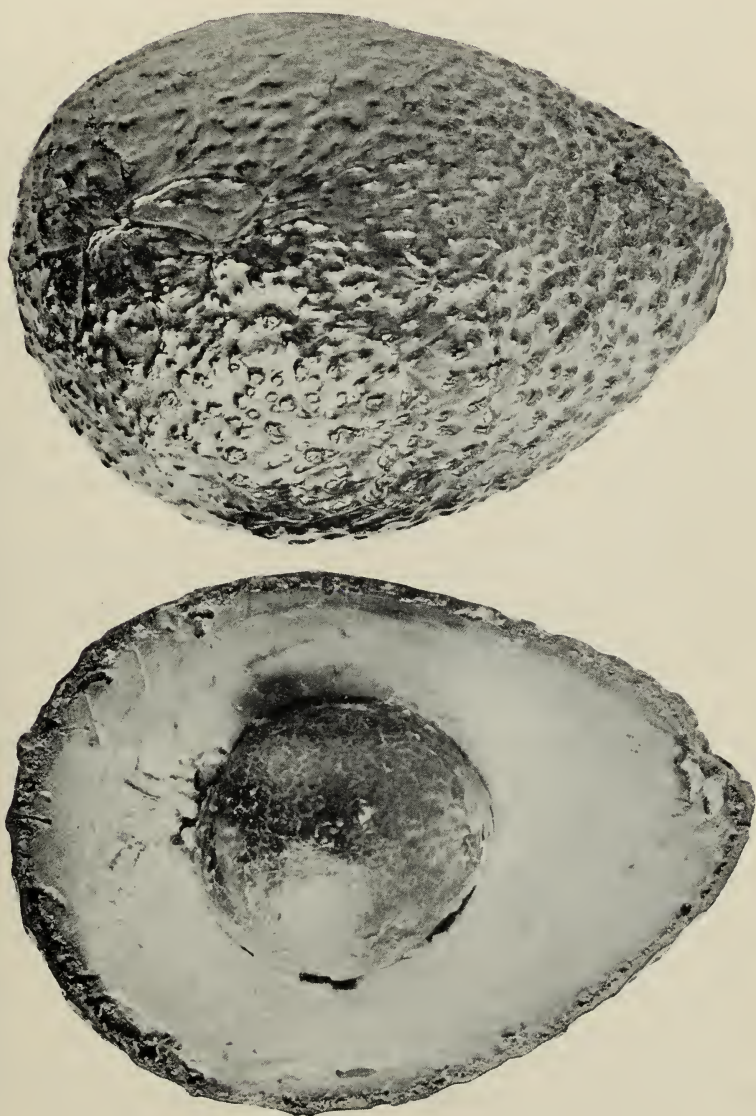


Fig. 20.—Dickinson, a dark purple variety with rough, thick skin or shell and a small tight seed. Season, April to October. This specimen is rather below normal size.

Fairhead.—Originated on place of G. E. Fairhead at Eagle Rock, California, in 1917. Fruit pyriform to broad oval, 14 to 20 ounces, slightly roughened, mahogany-purple. Seed medium. Season, March and April. Guatemalan.

Fuerte.—Description given above.

Garcia.—Originated on place of M. Garcia, Duarte, California, in 1921. Fruit pyriform, 15 ounces, smooth, green. Seed medium, sometimes loose. Season, January and February. Guatemalan.

Kashlan.—A Popenoe introduction from Guatemala, No. 10 (S. P. I. No. 43934). Fruit round or broadly oval; 20 ounces, smooth, green. Seed unusually small. Season, May and June. Guatemalan.

Linda.—Introduced from Guatemala by E. E. Knight of Yorba Linda, California, as No. 29 in 1914. Fruit round to elliptical, large, 32 to 36 ounces, rough, deep purple. Seed medium. Season, May to October. Guatemalan.

Lyon.—Originated in Hollywood, California, in 1908. Fruit oblique pyriform, 14 to 18 ounces, rough, dark green. Seed large. Season, April to July. Tree inclined to dwarfiness due to overbearing. Guatemalan.

Mayopan.—Introduced by Popenoe from Guatemala as No. 23 (S. P. I. No. 44680). Fruit nearly round, 14 to 20 ounces, slightly rough to corrugated, purple. Skin very thick. Seed small to medium. Season, May to August. Guatemalan.

Nabal.—Description given above.

Northrop.—Originated on the old Northrop place near Tustin, California, about 1900. Fruit oblong-pyriform, 5 to 7 ounces, smooth, purple. Seed medium. October and November. Mexican.

Panchoy.—Introduced by Popenoe as No. 18 (S. P. I. No. 44625) from Guatemala. Fruit broadly obovoid, 20 to 30 ounces, rough, green. Skin thick; seed small. June to August. Guatemalan.

Premier.—Originated on place of A. R. Rideout at Whittier, California. Fruit round, green, 15 to 20 ounces. Season, May to October. Guatemalan.

Puebla.—Description given above.

Queen.—Description given above.

Stephens Choice.—Sometimes known as Choice. Introduced from Atlixco, Mexico, by Wm. Stephens of Montebello, California. Fruit slightly pyriform to round, 16 to 20 ounces, smooth, green. Seed medium to large. Season, June to August. Guatemalan.

Taft.—Description given above.

Thompson.—Originated on place of Miss Jessie Thompson at Montebello, California, in 1913. Fruit long-pyriform, 14 to 21 ounces,

slightly pebbled, dark purple. Seed very small. Season, March to June. Guatemalan.

Tiger.—Originated at Bishop nursery, Highland, California. Fruit pyriform, 10 to 16 ounces, rough, glossy, purple. Seed medium. Season, February to May. Especially adapted to interior districts. Guatemalan.

Tumin.—A Popenoe introduction from Guatemala, No. 20 (S. P. I. No. 44627). Fruit spherical, slightly oblate, 18 to 24 ounces, smooth, unusually glossy, purplish-black. Seed medium to small. Fruit colors several months before ripening. Season, September. Guatemalan.

Worsham.^{*}—Originated at Whittier, California, in 1910. Fruit oblique-oval, 12 to 14 ounces, smooth, green, glossy. Seed medium to large. Tree very prolific. Season, December to February. Thought to be a Guatemalan-Mexican hybrid.

VARIETIES MOST HARDY TO COLD. SUGGESTED FOR AMATEUR GROWERS

Varieties marked with an asterisk (*) are especially recommended.

Blake.—Originated at Pasadena, California, about 1903. Fruit small, slender-pyriform, smooth, light green. Seed medium. Season, October and December. Mexican.

Caliente.—Description given above.

Dorothea.—Description given above.

Duke.^{*}—Description given above.

Fuerte.^{*}—Description given above.

Northrop.^{*}—Description given above.

Puebla.^{*}—Description given above.

Snell.—Originated at Sierra Madre, California. Fruit slender-pyriform, 5 to 7 ounces, green. Season, October to November. Very high in fat content. Mexican.

Topa-Topa.—Originated on old Thatcher place at Nordhoff, California, in 1907. Fruit oblique elongated-pyriform, 6 to 10 ounces, glossy, purple. Seed medium. September to December. Mexican.

More detailed information concerning these and the numerous other varieties which have been developed is available in the annual reports of the Variety Committee of the California Avocado Association which are published in the yearbooks of the Association, the headquarters of which are maintained at 1405 East Eighth Street, Los Angeles.

Fruits of all promising or interesting seedlings or introductions should be submitted to the committee for classification, study and rating.

UNITED STATES DEPARTMENT OF AGRICULTURE INTRODUCTIONS

The assistance of the United States Department of Agriculture in introducing promising avocado varieties has already been alluded to. In 1917 about twenty-three superior varieties were brought in from Guatemala, representing the best fruits selected by Popenoe in his explorations in that country extending over a period of several years. Full descriptions and illustrations of these fruits have already appeared.¹² They have now been under test and observation in California sufficiently long to have attracted widespread interest. A number of them are already being propagated by the nurserymen. Several of these varieties are especially promising, including Nabal, Benik, Cantel, Kashlan, Mayopan, Panchoy and Tumin.

More recently five new large-fruited varieties have been introduced from the Chota Valley, Ecuador, following explorations by Wilson Popenoe in 1921.¹³ Trees of each of these varieties are now under trial in southern California. They give promise of being valuable additions to the present list of hardy varieties.

USES OF THE FRUIT

The avocado is used principally as a salad food. As its general food value becomes more appreciated it will undoubtedly find a much larger place in the dietary of the American public. A discussion of its nutritive value is given in Part II of this publication. In addition to its common use for salads, a considerable number of methods of using the fruit have been devised by housewives and chefs, including avocado ice cream, sandwich filling and others. The reception with which these innovations have been met is indicative of the popularity the avocado will enjoy once it is placed on the market in sufficient quantity and at a price within reach of all.

The demand thus far has readily taken care of all the fruits produced—good, bad, and indifferent. The question of disposing of

¹² Popenoe, Wilson. The avocado in Guatemala. U. S. Dept. Agr. Dept. Bul. 743: 1-69. 1919.

Popenoe, Wilson. Exploring Guatemala for desirable new avocados. California Avocado Association Annual Report 1917: 104-138. 1918.

¹³ Popenoe, Wilson. Avocados of the Chota Valley, Ecuador. California Avocado Association Annual Report 1922: 35-39. 1923.

second and third grade fruit has not become at all pressing. There may come a time in the future when some other outlet will have to be developed for these grades. Preliminary experiments with a view to developing possible by-products have been undertaken both by the Agricultural Experiment Station, University of California, and by the Bureau of Chemistry of the United States Department of Agriculture. At the present time by far the most promising products are an ice cream base and bases for the preparation of cocktails and salads developed by the Division of Fruit Products of the University of California. Experiments on canning avocados have thus far failed to develop a satisfactory product. Studies looking to the development of methods of extracting avocado oil and possible uses for the product are under way at the present time.

Recent experiments in dehydration of the avocado by Cruess and Christie have indicated that a satisfactory product can be produced that will return to a satisfactory fresh condition when soaked from five to six hours in water. Many different tests were conducted. The most satisfactory results were obtained from the following procedure: The fruit is halved and peeled. It is then cut into slices a quarter of an inch or less in thickness. These slices are placed on wooden trays and subjected to the fumes of burning sulfur for fifteen minutes. They are then dehydrated to a bone dry consistency through the use of a temperature of not less than 140° Fahr. and not more than 180°. The drying ratio is between 5 and 6 to 1. To avoid rancidification of the oil, the product so prepared is packed in vacuum sealed jars. On soaking in slightly salted water the fruit returns to its original size and appearance in five or six hours. The flavor is not quite as rich nor quite as pleasing as that of the fresh fruit. However, when cut in small pieces and mixed with mayonnaise dressing it makes a very pleasing salad.

YIELDS AND RETURNS

The wide variation in yields of seedling and budded trees in California makes a satisfactory discussion of this subject difficult. One point is certain, namely, that the practice of estimating returns on the basis of the large crops borne by old seedling trees cannot be relied upon with any measure of safety. While it is true that some of these of both Guatemalan and Mexican types have produced as high as 2500 to 3000 fruits in a single season, budded trees are slower in growth and so far have not shown a tendency toward bearing abnormally large crops. There has not been sufficient time yet for trees planted under

orchard conditions to demonstrate the kind of crops they will consistently produce. At best, conservative estimates alone are safe. From observations made to date it would seem that a mature bearing orchard tree of from ten to fifteen years of age should produce a yearly average of 150 pounds of marketable fruit.

As to the prices which growers may reasonably expect in the future, there is much diversity of opinion. The food value of the avocado is much higher than that of any other fresh fruit, and many growers believe this fact alone will be sufficient to maintain relatively high price levels. On the other hand, it appears reasonable to conclude that, as in the case of all other fruits, price levels will be determined entirely by the relation between supply and demand. These relations have been such in recent years as to result in relatively high prices. As to whether the demand can be increased rapidly enough to maintain present price levels is a question which only the future can answer. It seems reasonable, however, to believe that general and fairly pronounced declines in price levels for avocados are inevitable. In any event it is certain that supplies of avocados in the United States will increase rapidly for some years to come. The normal increase in production in California alone will be manyfold in the next decade. Some of the leaders in the industry feel that before consumptive demand for avocados can be developed to the point where it will be sufficient to utilize all of the avocados California can produce, price levels must drop to 10 or 12 cents per pound. It is of interest in this connection to note that the Florida growers have in the past averaged from 6 to 8 cents per pound on the tree.

Figures covering costs of production are not available, but these are probably comparable to those involved in citrus fruit production, the usual range of which is from 200 to 350 dollars per acre. While at present, costs of insect pest and disease control are lower than with the citrus fruits, in all probability these are destined to increase as insects and diseases become more serious and wide spread. Moreover, costs of frost and wind protection will probably average somewhat higher than for the citrus fruits.

OUTLOOK---PRESENT AND FUTURE

That the avocado has come to stay as an important crop in California is assured beyond a doubt. With the ever increasing land values, especially in the more climatically favored portions of the state, crops yielding high gross returns per acre must be grown. As population becomes more and more dense the tonnage of food produced per acre must likewise increase; the food value of the fruit and its potentially high production per acre are sufficient reasons to justify its place in California agriculture.

Regardless of its promising future, however, certain conditions surrounding the growing industry should be clearly recognized. Avocado growing is a new industry and is far from being either standardized or stable. The initial investment in land and in nursery trees required is high, the risks are perhaps greater than with the well established fruit industries. The costs of production are not low; the avocado is a tender crop and requires unusual care; frost protection must be almost universally provided if investments are to be protected. Adequate capital must be available to carry the grower through until the trees arrive at a productive bearing age and to provide sufficient care without fail all during this initial period.

At the present stage of development avocado growing is not an industry for the inexperienced person of limited means. The efforts being made by some individuals and companies in California and Florida to attract the small investor with the hope of large returns, based on the behavior of exceptional trees and abnormal prices, cannot be too strongly condemned. The industry cannot develop with safety on such a basis.

Before the industry can become stabilized, much investigational work will be required. Hardy varieties which consistently produce good crops of high quality fruit are yet to be developed. The avocado districts of the world have been combed for varieties most suited to California conditions, and material is here from which to develop these varieties. Much progress has already been made in that direction.

So far no attempts have been made to improve the avocado by breeding. The value of the fruit as a food product lies in its high oil, mineral, and protein content. At present the oil content varies from 9% to 32% and the protein content from 1.3% to 4.6%; obviously from a nutritional point of view the best varieties should have a maximum content of oil and protein provided flavor and quality are

also maintained. The development of the fruit in this direction lies largely in the hands of the plant breeder. The effect of environmental conditions on the quality and composition of the fruit, however, must not be lost sight of and a thorough study of the influence of such factors still remains to be made.

The behavior of chance seedlings scattered through northern and central California indicates the possibilities of the development of hardy varieties suited to the climatic conditions of those sections. The future will undoubtedly witness breeding and selection investigations with a view to greatly expanding the area in which this valuable fruit can be grown. Many sections in southern California also await the development of hardier varieties than those now available.

The area in the United States in which the present varieties of avocados can be successfully grown is decidedly limited, occurring only in certain especially favored sections of California and Florida. On account of dangerous insect pests avocados cannot be shipped into the United States from the American tropics, with a few exceptions only, mainly Cuba.

On the other hand, it should be remembered, however, that the avocado acreage in Florida and California, while relatively small, can still be very greatly expanded, and that the possibilities in Cuba are even greater than in the two states combined.

It is certain that ever increasing, intensive competition faces the California avocado grower. Present price levels will in all probability decline, and the maintenance of relatively high price levels will eventually advance land values to the point where the interest on the investment will materially reduce the net returns.

Like all other young horticultural industries, avocado production may be expected to have its ups and downs before it is eventually stabilized on a moderately profitable basis. There is much reason for believing that within the next decade the industry will have passed through the exploitation stage and settled down to a commercial basis when the profits will not be materially different from those of other California specialty subtropical fruits such as the orange, lemon, grapefruit or date.

In any event, the future success of the industry depends on the employment by the growers of the same methods which have brought success to the growers of other California fruit crops, namely the production of the best possible quality fruit, the preparation of it for market in the most attractive manner, rigid adherence to grading and standardization, and the use of the most efficient merchandizing methods.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to F. O. Popenoe of Altadena, Wm. Hertrich of El Molenito, Dr. J. Eliot Coit of Pasadena, and other members of the California Avocado Association for helpful suggestions and criticisms in connection with the preparation of the manuscript for the first edition of this bulletin.

He is especially indebted to Professor Robert W. Hodgson of the Division of Subtropical Horticulture of the College of Agriculture for assistance in the preparation of the original bulletin and for its revision and expansion into the present publication. In this revision valuable suggestions were received from Geo. B. Hodgkin, Secretary-Manager of the Calavo Growers of California, Mrs. Adeltha Peterson, Secretary to Mr. Hodgkin; E. C. Dutton of Anaheim, President of the California Avocado Association, and Dr. J. Eliot Coit, Chairman of the Association Committee on Varieties, for which grateful acknowledgment is hereby made.

THE NUTRITIVE VALUE OF THE AVOCADO

PART II

M. E. JAFFA AND H. GOSS

The investigation¹⁴ here reported includes 110 analyses representing 68 different varieties of the avocado. These data emphasize the value of this fruit as an excellent source of easily digested vegetable fat.

THE AVERAGE COMPOSITION OF FRESH FRUITS

A reference to the composition of fresh fruit in general shows that the amount of water is large, averaging about 83 per cent, and that the percentage of the nutrients indicates that the main food value is derived from carbohydrates. In nearly all cases sugars predominate, starch being present in small amounts only.

The protein content of fruits is low, averaging for the loquat about 0.2 of one per cent; apples and pears, 0.4–0.5 per cent; fresh prunes, 0.9 per cent; melons, 0.5 per cent; berries, 1–1.3 per cent; oranges, 0.8–1.0 per cent; grapes and bananas, 1.2–1.5 per cent. The average, therefore, for protein for the fresh fruits enumerated is practically 0.72 per cent. The olive contains approximately 2.5 per cent protein.

The per cents for the mineral matter or ash in fresh fruits are as follows: apples and pears, 0.3–0.4; grapes, 0.5; figs, 0.6; berries, 0.6; oranges, 0.5; melons, 0.5; fresh prunes, 0.6; bananas, 1.0. The average being 0.55 per cent, while the corresponding figure for meat is about 1 per cent.

It must not be forgotten, however, that while the *amount* of ash is small, the percentage of potassium in the ash is high. This is a very valuable base-forming element which is necessary in the maintenance of the normal neutrality of the blood and tissues. The importance of the mineral matter in nutrition and the necessity of carefully selecting the dietary so as to secure a proper balance between the base-forming and acid-forming elements is becoming more and more apparent.

¹⁴ Credit is due to Miss Mattie E. Stover and F. W. Albro for assistance in chemical work incidental to this investigation.

Fat is present in very small proportions in fresh fruits. This constituent is generally reported as "ether extract" which often contains other materials than the true fats or oil, such as coloring matter, wax found in the skin, etc. The figure reported for fat in most fruits, therefore, is seldom a true indication of the content of this nutrient.

Fruits are important sources of water-soluble vitamins. Particularly is this true of the citrus fruits which are rich in vitamin C. The deciduous fruits shown appreciable percentages of B and berries, like raspberries and strawberries, show also a high content of vitamin C.

Mature California grown fruits only are included in above tabulation.

COMPOSITION OF THE AVOCADO

A survey of the data presented in the accompanying tables shows the avocado to differ widely in many respects from the average for fresh fruits and proves it worthy of special consideration. It might well be said to be in a class by itself.

The tables are replete with interesting points, all very favorable to the avocado. The total dry matter in the edible portion is, in nearly every instance, greater than that noted for any other fresh fruit. The average for the avocado, based on examination of mature California fruits is 29.44 per cent. The nearest approach to this figure is found in the banana with about 25 per cent dry matter. It must be remembered, however, that while there may not be so much difference in the total amount of solids of the two fruits in question, there is a great difference in the nature of the nutrients. Sugar and starch predominate in the banana as against fat in the avocado.

It has been stated that the protein per cent in all fruits is low, averaging less than one per cent. It will be seen from the table that the minimum figure for protein in the avocado is 1.14, which is about 75 per cent of the maximum, 1.5 per cent, noted for figs and currants. The maximum, 4.39 per cent, credited to Bartley avocado grown at Santa Ana, corresponds to the protein content of some *dried* fruits.

It is of interest in passing to note that a sample of the Lyon variety analyzed by the U. S. Department of Agriculture also shows the same figure, 4.39 per cent, as the maximum for the protein for this variety.

In seven of the varieties the protein is in excess of 3 per cent; in 36 varieties between 2 and 3 per cent; while the average for 83 mature varieties is 2.10 per cent.

It therefore may be said that so far as protein in fresh fruits is concerned, the avocado stands in the lead.

TABLE 1.—SHOWING THE COMPOSITION OF THE AVOCADO

Variety	Locality	Weight of fruit grams	Refuse per cent	Edible portion				
				Water per cent	Protein per cent	Fat per cent	Carbo- hydrates per cent	Ash per cent
1. Azusa.....	Azusa.....	198	28.30	67.05	1.94	21.06	8.59	1.36
2. Azusa.....	Azusa.....	169	13.60	62.69	2.91	26.44	6.15	1.81
Average Azusa.....		184	21.00	64.87	2.43	23.75	7.37	1.58
3. Bartley.....	Santa Ana.....	928	21.33	77.12	4.39	13.35	3.74	1.40
4. Beauty.....	Orange.....	426	34.07	72.68	2.48	15.26	8.22	1.36
5. Benik.....	Duarte.....	518	31.06	69.98	1.97	22.02	4.42	1.61
6. Blake.....	Pasadena.....	150	32.66	65.76	1.88	25.50	5.52	1.34
7. Blake.....	Whittier.....	120	31.60	68.24	1.81	21.65	8.18	1.12
8. Blakeman.....	Altadena.....	472	30.30	74.33	2.61	17.27	4.94	0.85
9. Blakeman.....	Altadena.....	454	20.81	77.72	3.15	15.43	2.59	1.11
Average Blakeman.....		463	25.57	76.87	2.88	16.35	3.76	0.98
10. Brodia.....	Orange.....	405	36.80	80.80	1.26	10.88	6.30	0.76
11. Cabnal.....	Duarte.....	459	33.11	67.15	2.08	23.71	5.69	1.37
12. Cantel.....	Duarte.....	351	24.79	72.04	2.43	19.00	4.90	1.59
13. Cardinal.....	Florida.....	587	19.00	79.66	2.56	10.70	6.48	0.60
14. Caribou.....	Duarte.....	464	31.04	82.31	1.34	10.33	4.60	1.42
15. Caribou.....	Duarte.....	486	19.80	79.02	2.21	12.00	5.43	1.34
Average Caribou.....		475	25.42	80.66	1.77	11.17	5.02	1.38
16. Carmen.....	Altadena.....	139	31.30	63.39	1.22	26.38	7.46	1.55
17. Carton.....	San Fernando.....	169	41.20	70.43	2.60	19.50	6.29	1.18
18. Carton*.....	Riverside.....	108	26.06	78.32	1.38	12.71	6.60	0.99
19. Challenge*.....	Hollywood.....	1060	40.57	79.61	3.43	13.14	2.62	1.20
20. Challenge.....	Hollywood.....	669	17.78	76.23	2.81	16.37	3.05	1.54
21. Champion.....	Orange.....	506	30.00	74.32	2.59	16.54	5.31	1.24
22. Chappelow.....	Monrovia.....	181	22.43	60.94	1.40	29.10	6.85	1.71
23. Chappelow.....	Monrovia.....	173	31.00	63.58	2.63	24.43	8.06	1.30
24. Chappelow.....	Monrovia.....	104	36.34	63.74	2.19	22.81	10.00	1.26
25. Chappelow.....	Monrovia.....	110	36.90	58.99	2.79	27.66	9.33	1.23
26. Chappelow.....	Monrovia.....	159	23.30	70.77	2.25	20.28	5.13	1.57
Average Chappelow.....		145	29.99	63.61	2.25	24.85	7.88	1.41
27. Chappelow*.....	Altadena.....	80	30.30	75.34	2.30	14.66	6.80	0.90
28. Condon.....	Pasadena.....	143	34.20	69.11	2.50	21.00	6.73	0.66
29. Condon.....	Pasadena.....	150	24.00	70.30	1.31	23.55	3.62	1.22
Average Condon.....		146	29.10	69.70	1.91	22.28	5.17	0.94
30. Dickey.....	Hollywood.....	363	30.00	60.50	2.20	27.11	8.76	1.43
31. Dickey*.....	Nordhoff.....	560	24.55	81.10	2.01	11.81	3.75	1.33
32. Dickinson.....	Puente.....	254	29.99	72.04	1.56	20.36	4.69	1.35
33. Fowler.....	Pasadena.....	132	35.80	70.33	1.60	21.20	5.61	1.26
34. Fuerte.....	Yorba Linda.....	315	25.71	66.30	1.42	25.32	5.68	1.28
35. Fuerte.....	Yorba Linda.....	566	26.14	68.32	1.36	24.23	4.82	1.27
Average Fuerte.....		440	25.92	67.31	1.39	24.77	5.25	1.28
36. Fuerte*.....	Yorba Linda.....	254	23.62	80.88	1.04	11.61	5.53	0.94
37. Fuerte.....	Altadena.....	270	26.48	65.26	1.40	28.68	3.22	1.44
38. Fuerte.....	Altadena.....	256	28.71	65.67	1.51	26.60	4.62	1.60
Average Fuerte.....		263	27.59	65.46	1.46	27.61	3.92	1.52
39. Ganter.....	Whittier.....	205	16.60	63.86	2.25	25.60	6.58	1.71
40. Ganter*.....	Whittier.....	197	26.80	77.87	2.13	16.48	2.48	1.04
41. Harman*.....	Sherman.....	127	35.50	75.17	1.69	15.25	7.00	0.89
42. Harman*.....	Sherman.....	136	37.90	76.09	1.24	15.34	6.65	0.68
43. Harman*.....	Sherman.....	170	37.40	75.42	1.47	16.26	5.86	0.99
Average Harman*.....		144	36.93	75.56	1.47	15.62	6.50	0.85
44. Harman.....	Sherman.....	235	46.38	71.58	2.50	19.33	5.32	1.27
45. Harman.....	Sherman.....	263	34.70	74.70	1.60	18.30	4.60	0.80
46. Harman.....	Sherman.....	233	33.50	72.05	1.43	21.51	4.24	0.77
47. Harman.....	Sherman.....	215	34.90	73.44	1.14	18.68	5.17	1.57
48. Harman.....	Sherman.....	192	28.00	72.75	1.16	19.18	5.86	1.05
Average Harman mature.....		227	41.61	72.90	1.57	19.40	5.03	1.10

* Immature.

TABLE 1.—(Continued)

Variety	Locality	Weight of fruit grams	Refuse per cent	Edible portion				
				Water per cent	Protein per cent	Fat per cent	Carbo- hydrates per cent	Ash per cent
49. I. X. L.*	Duarte	705	31.60	84.27	2.12	7.50	4.70	1.41
50. I. X. L.	Duarte	800	23.00	78.12	2.17	13.47	4.74	1.50
51. Kist	Yorba Linda	456	31.35	76.84	1.51	12.16	8.13	1.36
52. Kist	Yorba Linda	478	28.20	74.71	2.41	14.92	6.49	1.47
Average Kist		467	29.77	75.78	1.96	13.54	7.31	1.41
53. Lamat	Duarte	332	30.42	77.32	1.42	14.29	5.57	1.40
54. Lambert	Hollywood	285	33.40	76.52	2.86	14.31	5.40	0.91
55. Lyon	Hollywood	453		75.78	2.48	16.31	4.38	1.05
56. Lyon	La Habra	453	26.50	74.80	2.76	15.58	6.01	0.85
57. Mattern	Unknown	92	44.00	61.55	2.20	25.70	8.94	1.61
58. Mayapan	Duarte	397	37.28	68.33	1.77	22.83	5.59	1.48
59. Mayapan	Duarte	449	28.06	70.26	2.25	21.80	4.13	1.56
Average Mayapan		423	32.67	69.29	2.01	22.32	2.86	1.52
60. Meserve	Puente	331	40.00	74.66	2.19	17.01	4.78	1.36
61. Miller	Hollywood	184	35.80	66.60	3.70	23.70	4.51	1.49
62. Miller	Pasadena	275	40.00	63.68	3.36	27.45	4.18	1.33
63. Monrovia	Altadena	166	37.00	64.18	2.09	25.34	6.73	1.66
64. Nimlich	Duarte	860	24.42	78.55	1.53	13.93	4.83	1.16
65. Northrop	Santa Ana	164	34.70	66.31	2.36	23.00	7.12	1.21
66. Pankay	Duarte	385	41.30	73.15	1.58	14.56	9.10	1.61
67. Pankay	Duarte	310	46.12	71.03	1.64	16.30	9.61	1.42
Average Pankay		347	43.76	72.09	1.61	15.43	9.36	1.51
68. Pomona	Sacramento	79	43.00	61.84	3.50	25.36	7.36	1.94
69. Popenoe 101	Altadena	327	23.82	58.71	2.39	31.59	5.65	1.66
70. Popenoe 101	Altadena	375	29.34	60.78	1.82	29.78	5.92	1.70
Average Popenoe 101		346	26.58	59.74	1.65	30.68	5.78	1.68
71. Puebla*	Altadena	168	34.00	80.59	1.76	11.32	5.22	1.11
72. Puebla	Altadena	280	27.50	69.47	1.66	20.94	6.65	1.28
73. Puebla	Altadena	158	36.00	67.53	1.83	26.14	3.16	1.34
Average Puebla mature		219	31.75	68.50	1.74	23.54	4.91	1.31
74. Purdy	Whittier	168	32.10	60.28	1.14	31.60	5.49	1.49
75. Purple Prolific	Orange	219	45.90	69.30	1.67	19.93	8.27	0.83
76. Queen	Unknown	663	29.15	73.80	2.21	16.35	6.01	1.63
77. Queretaro	Yorba Linda	217	37.80	71.46	2.85	17.45	6.79	1.45
78. Queretaro	Altadena	164	36.60	71.46	2.34	18.21	6.56	1.43
79. Rhoad	Orange	395	37.00	82.46	1.19	9.78	6.03	0.54
80. Rita*	Orange	321	42.68	71.05	1.57	14.13	12.25	1.00
81. Royal	Hollywood	600	26.33	76.34	1.39	15.61	5.97	0.69
82. Royal Purple	San Diego	200	26.00	72.96	1.72	19.39	4.84	1.09
83. Senor	Orange	528	21.00	74.70	1.69	17.03	5.45	1.13
84. Sharpless*	Santa Ana	471	21.23	76.73	2.15	15.73	3.69	1.70
85. Sharpless*	Santa Ana	555	22.50	75.33	3.06	15.87	4.52	1.22
Average Sharpless*		513	21.86	76.03	2.60	15.80	4.11	1.16
86. Sharpless	Santa Ana	594	23.10	71.21	1.70	20.54	5.43	1.12
87. Sharpless	Santa Ana	536	24.10	72.63	1.27	18.77	6.39	0.94
Average Sharpless		565	23.65	71.92	1.48	19.65	5.91	1.03
88. Sinaloa	Whittier	616	23.40	73.55	2.67	16.43	5.57	1.78
89. Spinks	Duarte	388	31.50	76.22	1.50	14.83	5.96	1.49
90. Spinks	Duarte	877	20.30	75.72	2.10	16.01	4.74	1.43
Average Spinks		633	25.90	75.97	1.80	15.42	5.35	1.46
91. Surprise	Hollywood	538	26.00	82.51	1.90	9.96	4.86	0.77
92. Taft	Orange	626	29.00	72.53	2.66	18.54	5.16	1.11
93. Taft*	Orange	417	25.00	76.11	2.30	14.67	6.00	0.92
94. Taft*	Orange	296	27.00	77.25	3.44	12.59	4.91	1.81
Average Taft*		356	26.00	76.68	2.87	13.63	5.45	1.37
95. Oopa-Topa	Nordhoff	123	27.70	75.00	2.30	15.48	6.14	1.08
96. Trapp	Florida	638	28.50	78.66	1.61	9.80	9.08	0.85

* Immature.

TABLE 1.—(Continued)

Variety	Locality	Weight of fruit grams	Refuse per cent	Edible portion				
				Water per cent	Protein per cent	Fat per cent	Carbo- hydrates per cent	Ash per cent
97. Ultimate.....	Orange.....	277	37.40	75.01	1.57	14.51	4.88	1.03
98. Walker.....	Sherman.....	174	37.10	68.66	3.15	18.71	7.55	1.93
99. Wagner.....	Hollywood.....	259	47.00	74.84	2.77	16.03	5.05	1.30
100. Dr. Weldon.....	Duarte.....	450	41.00	63.75	2.57	24.29	7.79	1.60
101. W. I. G.....	Altadena.....	123	28.50	60.00	2.63	26.73	9.08	1.56
102. White.....	Santa Barbara.....	162	35.00	77.06	1.74	14.64	5.49	1.07

	No. of analyses	Weight of fruit grams	Refuse per cent	Water per cent	Protein per cent	Fat per cent	Carbo- hydrates per cent	Ash per cent
Maximum.....	83	928	47.00	82.31	4.39	31.60	10.00	1.94
Minimum.....	83	79	13.60	58.71	1.14	9.78	2.59	0.54
Average.....	83	347	32.11	70.56	2.10	20.06	5.95	1.32

Mature California grown fruits only are included in above tabulation.

PARTIAL ANALYSES

Variety	Locality	Weight of fruit grams	Refuse per cent	Water per cent	Fat per cent
1. Atlixco.....	Yorba Linda.....	352	26.52	63.70	28.80
2. Atlixco.....	Yorba Linda.....	532	26.86	63.10	26.90
Average Atlixco.....		442	26.69	63.40	27.95
3. Goldie.....	San Diego.....	165	35.50	56.50	26.67
4. Knight.....	Yorba Linda.....	570	26.95	71.03	23.31
5. Linda.....	Unknown.....	890	20.23	82.66	7.48
6. Snell.....	Sierra Madre.....	306	29.00	55.00	32.70
7. Tahiti.....	San Diego.....	256	19.50	50.60	23.20
8. Whittier.....	Whittier.....	687	23.00	75.20	21.20

The carbohydrate content of the avocado is low as compared with this constituent in fresh fruits. The average for the 83 mature varieties is 5.95 per cent, with a maximum of 10 per cent and a minimum of 2.59 per cent.

The figures quoted in the table for carbohydrates include crude fiber which was not determined in every case. Analyses of a number of samples have shown, however, that this ingredient would average about 1.5 per cent, which compares very favorably with the content of crude fiber in other fresh fruits.

It is of decided interest to note that the percentage of mineral matter in the avocado is much higher than that recorded for any other fresh fruit. The minimum 0.54 per cent, reported for the Rhoad variety, equals approximately the average for most of our fresh fruits, while the average for the avocado, 1.32 per cent, shows that it contains twice as much mineral matter as that yielded by any other fruit.

The following analysis of the ash of the avocado shows that, like other fruit, the avocado yields an excess of the base-forming elements:

Silica	0.50
Phosphoric acid	17.40
Lime	4.72
Magnesia	5.30
Iron	1.51
Aluminum	2.58
Manganese	Trace
Sulfuric acid	11.24
Chlorin	14.36
Potash	26.23
Soda	18.55
	101.89
Oxygen equivalent to chlorin	2.09
	99.80

Nearly one-half of the ash consists of soda and potash, the latter predominating. Magnesia and lime occur in comparatively small amounts, about 5 per cent each; the phosphoric acid averaging about 17.5 per cent, with 1.5 per cent of iron.

The foregoing discussion clearly indicates that so far as protein and ash in fresh fruits are concerned, the avocado stands at the head of the list, and with reference to the carbohydrates, contains on an average fully 50 per cent of that found in many fresh fruits. These facts alone would warrant due consideration of the value of the avocado as a fresh fruit.

The chief value of the avocado as food, however, is due to its high content of fat. This varies, as shown by the analyses, from a minimum of 9.78 per cent to a maximum of 31.6 per cent, with an average of 20.6 per cent.

Reviewing the analytical data, it will be seen that 15 varieties show more than 25 per cent fat and 14 other varieties an excess of 20 per cent. The only fruit comparable with the avocado in this respect is the olive. In this connection, it is of interest to note the comparison as shown in the following table, of the fat percentages of the edible portion of ten varieties of the avocado containing 25 per cent or more of fat, with ten varieties of the olive.

The figures in table 2 indicate that the avocado ranks higher in fat or oil than the average or commonly used olive. The olive also has the disadvantage of requiring special treatment before it is ready for consumption and should really rank as a processed fruit rather than a fresh one. The data in the table show that, when considering the dry matter only, the Purdy has the highest percentage of fat. In the original condition, the Blake and the Chappelow differ in fat by

nearly 4 per cent, which difference is practically eliminated when comparison is made on a water-free basis, which is the only true way to compare the nutritive value of fruits.

TABLE 2.—SHOWING PERCENTAGE OF FAT OR OIL IN THE AVOCADO AND OLIVE

AVOCADO—EDIBLE PORTION				OLIVE—EDIBLE PORTION		
Variety	<i>Original material</i>		<i>Water-free</i>	<i>Original material</i>		Per ct. oil
	Per ct. water	Per ct. fat		Variety		
Purdy.....	60.28	31.60	79.70	Corregiolo.....		27.68
Popenoe.....	59.74	30.68	76.20	Nigerina.....		26.16
Chappelow.....	60.94	29.10	74.40	Nevadillo Blanco.....		22.92
Fuerte.....	65.26	28.68	82.50	Mission.....		22.51
Miller.....	63.68	27.45	75.60	Rubra.....		22.01
Dickey.....	60.50	27.11	68.70	Pendulina.....		21.36
Azusa.....	62.69	26.44	70.90	Redding Picholine.....		20.83
Carmen.....	63.39	26.38	72.10	Macrocarpa.....		20.41
Ganter.....	63.86	25.60	70.80	Manzanillo.....		19.73
Blake.....	65.76	25.50	74.50	Columbella.....		19.54

CALORIC VALUE

While it is true that the real value of any food is not always represented by the heat units or calories, at the same time, the total food value is so indicated. This difference between the real food value and the total food value is not always properly understood. For instance, the energy value of a pound of sugar is 1820 calories, while the corresponding value for lean meat is less than 1000 calories. Yet we would hardly say that the real value of a pound of sugar was 1.8 times that of a pound of lean meat, if the question of growth were under consideration. When, however, the matter of energy is being discussed the case is entirely different, and the value of a food as a source of energy varies directly with its caloric value.

The energy values of the edible portion of the commonly used fresh fruits are low, ranging from a minimum of 175 calories to a possible maximum of 400 calories per pound.

TABLE 3.—SHOWING THE ENERGY VALUE OF THE AVOCADO

Variety	Energy value per pound calories	Variety	Energy value per pound calories
Azusa.....	1,235	Mayapan.....	992
Blake.....	1,083	Miller.....	1,159
Blakeman.....	783	Northrop.....	1,101
Cabnal.....	1,100	Pomona.....	1,223
Chappelow.....	1,184	Popenoe.....	1,376
Dickey.....	1,293	Puebla.....	1,026
Dickinson.....	958	Queen.....	812
Fuerte.....	1,187	Sharpless.....	928
Ganter.....	1,195	Sinaloa.....	814
Harman.....	904		
Lyon.....	785	Average.....	1,056

An inspection of table 3 shows that the avocado has a far higher value in this respect, the average for twenty varieties, being 1056 per pound, or more than twice the maximum (400 calories) noted for other fresh fruits. The minimum, 783 calories, approaches very closely to this figure. The maximum, 1376 calories per pound, corresponds to that noted for some varieties of *dried* fruits. It is practically 75 per cent of the fuel value of the cereals and far in excess of the fuel value of lean meat.

DIGESTIBILITY

Digestion experiments conducted by Mattill¹⁵ have shown that the digestion coefficient for avocado fat for man is 93.8, which is identical with the average obtained by Drs. Langworthy and Holmes in connection with the digestibility of butter fat by man. In other words, the digestibility of avocado fat is on a par with butterfat.

There have, however, been no metabolism experiments carried on in connection with the protein and carbohydrates of the avocado, yet it is only fair to assume that this fruit is as easily digested as many others whose coefficients have been determined. The availability of the fats and mineral matter are fully equal to that obtained for the mixed diet; and the digestion coefficients of the carbohydrates compare very favorably with the corresponding figures for other foods, but the availability of the protein is appreciably lower.

VITAMINS

Dr. Santos¹⁶ has shown that the avocado is an excellent source of vitamin B or the antineuritic vitamin. He found that one-half gram of the avocado as a daily supplement to the standard vitamin B free diet, caused a recovery in the weight of rats which has been declining because of lack of this accessory food factor.

Studies are now in progress by the Nutrition Division for the purpose of ascertaining the content of vitamin C in the avocado. This fruit is eaten raw and therefore if it proves to be high in vitamin C, its nutritional value will be greatly enhanced. There are many fruits and foods which contain appreciable amounts of vitamin C in the raw stage but which have to be processed or cooked before ready for con-

¹⁵ Mattill, H. A. The digestibility of the fat of the avocado. California Avocado Association Annual Report 1916: 93-95. 1917.

¹⁶ Santos, Francisco O. Some plant sources of vitamins B and C. Amer. Jour. Physiology 59: 310-334. 1922.

sumption, resulting in a great lowering of the potency of the anti-scorbutic vitamin. In some instances, cooking or processing is entirely destructive to this accessory food factor.

DIETETIC VALUE

The dietetic value of fruit, aside from the actual nutrients which it contains, lies in its succulency, its minerals, its vitamins, and its organic acids. If gauged by its nutritive value alone, fruit would seem to be an expensive form of nourishment, but when its hygienic qualities are considered its money value to the consumer is difficult to estimate. Some fruits carry more nourishment with their hygienic properties than others. Some contain minerals which are more valuable to the system or less commonly distributed than others. Again, there are the citrus fruits which are rich in vitamin C. Therefore, while there are general properties which are common to all fruits, each has special properties which justify individual consideration.

While the special dietetic value of a food can not always be forecast by the chemical analysis, it is certainly permissible to suggest the possibilities which are indicated by the results of such investigation. It is always necessary that such theory be confirmed by clinical experience.

Judging from its composition, the avocado should perhaps prove to have laxative qualities of a peculiar or individual type, possessing as it does the combination of the usual "fruit principles," and that of fat or oil. The laxative properties of most fruits depend upon the stimulating effects of the fiber upon the wall of the intestine and partly upon the organic acids and minerals. Oil has a tendency to soothe and to lubricate the intestine even while it acts as a mild laxative. The avocado is a natural combination of these two types of foods—as if fruit and olive oil had been chemically combined by nature. Whether or not there is any special advantage in this natural combination over that made by a proper selection of foods remains to be proved. There are no clinical data on the subject, but future experimental work may furnish some interesting results.

The fact that the native Cubans prefer this fruit to any other of their abundant supply may be due to its flavor alone, but it is more than likely that the preference has a deeper foundation and that it is the result of generations of experience or knowledge of its beneficial effects.

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THE NUTRITIVE VALUE OF THE
AVOCADO

BY

M. E. JAFFA *and* H. GOSS

PART II

THE NUTRITIVE VALUE OF THE AVOCADO*

BY

M. E. JAFFA and H. GOSS

The investigation here reported includes 110 analyses representing 68 different varieties of the avocado. These data emphasize the value of this fruit as an excellent source of easily digested vegetable fat.

THE AVERAGE COMPOSITION OF FRESH FRUITS

A reference to the composition of fresh fruit in general shows that the amount of water is large, averaging about 83 per cent, and that the percentage of the nutrients indicates that the main food value is derived from carbohydrates. In nearly all cases sugars predominate, starch being present in small amounts only.

The protein content of fruits is low, averaging for the loquat about 0.2 of one per cent; apples and pears, 0.4–0.5 per cent; fresh prunes, 0.9 per cent; melons, 0.5 per cent; berries, 1–1.3 per cent; oranges, 0.8–1.0 per cent; grapes and bananas, 1.2–1.5 per cent. The average, therefore, for protein for the fresh fruits enumerated is practically 0.72 per cent. The olive contains approximately 2.5 per cent protein.

The per cents for the mineral matter or ash in fresh fruits are as follows: apples and pears, 0.3–0.4; grapes, 0.5; figs, 0.6; berries, 0.6; oranges, 0.5; melons, 0.5; fresh prunes, 0.6; bananas, 1.0. The average being 0.55 per cent, while the corresponding figure for meat is about 1 per cent.

It must not be forgotten, however, that while the *amount* of ash is small, the percentage of potassium in the ash is high. This is a very valuable base-forming element which is necessary in the maintenance of the normal neutrality of the blood and tissues. The importance of the mineral matter in nutrition and the necessity of carefully selecting the dietary so as to secure a proper balance between the base-forming and acid-forming elements is becoming more and more apparent.

* Credit is due to Miss Mattie E. Stover and F. W. Albro for assistance in chemical work incidental to this investigation.

Fat is present in very small proportions in fresh fruits. This constituent is generally reported as "ether extract" which often contains other materials than the true fats or oil, such as coloring matter, wax found in the skin, etc. The figure reported for fat in most fruits, therefore, is seldom a true indication of the content of this nutrient.

Fruits are important sources of water-soluble vitamins. Particularly is this true of the citrus fruits which are rich in vitamin C. The deciduous fruits show appreciable percentages of B and berries, like raspberries and strawberries, show also a high content of vitamin C.

Mature California grown fruits only are included in above tabulation.

COMPOSITION OF THE AVOCADO

A survey of the data presented in the accompanying tables shows the avocado to differ widely in many respects from the average for fresh fruits and proves it worthy of special consideration. It might well be said to be in a class by itself.

The tables are replete with interesting points, all very favorable to the avocado. The total dry matter in the edible portion is, in nearly every instance, greater than that noted for any other fresh fruit. The average for the avocado, based on examination of mature California fruits is 29.44 per cent. The nearest approach to this figure is found in the banana with about 25 per cent dry matter. It must be remembered, however, that while there may not be so much difference in the total amount of solids of the two fruits in question, there is a great difference in the nature of the nutrients. Sugar and starch predominate in the banana as against fat in the avocado.

It has been stated that the protein percent in all fruits is low, averaging less than one per cent. It will be seen from the table that the minimum figure for protein in the avocado is 1.14, which is about 75 per cent of the maximum, 1.5 per cent, noted for figs and currants. The maximum, 4.39 per cent, credited to Bartley avocado grown at Santa Ana, corresponds to the protein content of some *dried* fruits.

It is of interest in passing to note that a sample of the Lyon variety analyzed by the U. S. Department of Agriculture also shows the same figure, 4.39 per cent, as the maximum for the protein for this variety.

In seven of the varieties the protein is in excess of 3 per cent; in 36 varieties between 2 and 3 per cent; while the average for 83 mature varieties is 2.10 per cent.

It therefore may be said that so far as protein in fresh fruits is concerned, the avocado stands in the lead.

TABLE 1.—SHOWING THE COMPOSITION OF THE AVOCADO

		Weight of fruit grams	Refuse per cent	Edible Portion				
Variety	Locality			Water per cent	Protein per cent	Fat per cent	Carbo- hydrates per cent	Ash per cent
1. Azusa.....	Azusa.....	198	28.30	67.05	1.94	21.06	8.59	1.36
2. Azusa.....	Azusa.....	169	13.60	62.69	2.91	26.44	6.15	1.81
Average Azusa.....		184	21.00	64.87	2.43	23.75	7.37	1.53
3. Bartley.....	Santa Ana.....	928	21.33	77.12	4.39	13.35	3.74	1.40
4. Beauty.....	Orange.....	426	34.07	72.68	2.48	15.26	8.22	1.36
5. Benik.....	Duarte.....	518	31.06	69.98	1.97	22.02	4.42	1.61
6. Blake.....	Pasadena.....	150	32.66	65.76	1.88	25.50	5.52	1.34
7. Blake.....	Whittier.....	120	31.60	68.24	1.81	21.65	8.18	1.12
8. Blakeman.....	Altadena.....	472	30.30	74.33	2.61	17.27	4.94	0.85
9. Blakeman.....	Altadena.....	454	20.81	77.72	3.15	15.43	2.59	1.11
Average Blakeman.....		463	25.57	76.87	2.88	16.35	3.76	0.98
10. Brodia.....	Orange.....	405	36.80	80.80	1.26	10.88	6.30	0.76
11. Cabnal.....	Duarte.....	459	33.11	67.15	2.08	23.71	5.69	1.37
12. Cantel.....	Duarte.....	351	24.79	72.04	2.43	19.00	4.90	1.59
13. Cardinal.....	Florida.....	587	19.00	79.66	2.56	10.70	6.48	0.60
14. Caribou.....	Duarte.....	464	31.04	82.31	1.34	10.33	4.60	1.42
15. Caribou.....	Duarte.....	486	19.80	79.02	2.21	12.00	5.43	1.34
Average Caribou.....		475	25.42	80.66	1.77	11.17	5.02	1.38
16. Carmen.....	Altadena.....	139	31.30	63.39	1.22	26.38	7.46	1.55
17. Carton.....	San Fernando.....	169	41.20	70.43	2.60	19.50	6.29	1.18
18. Carton*.....	Riverside.....	108	26.06	78.32	1.38	12.71	6.60	0.99
19. Challenge*.....	Hollywood.....	1060	40.57	79.61	3.43	13.14	2.62	1.20
20. Challenge.....	Hollywood.....	669	17.78	76.23	2.81	16.37	3.05	1.54
21. Champion.....	Orange.....	506	30.00	74.32	2.59	16.54	5.31	1.24
22. Chappelow.....	Monrovia.....	181	22.43	60.94	1.40	29.10	6.85	1.71
23. Chappelow.....	Monrovia.....	173	31.00	63.58	2.63	24.43	8.06	1.30
24. Chappelow.....	Monrovia.....	104	36.34	63.74	2.19	22.81	10.00	1.26
25. Chappelow.....	Monrovia.....	110	36.90	58.99	2.79	27.66	9.33	1.23
26. Chappelow.....	Monrovia.....	159	23.30	70.77	2.25	20.28	5.13	1.57
Average Chappelow.....		145	29.99	63.61	2.25	24.85	7.88	1.41
27. Chappelow*.....	Altadena.....	80	30.30	75.34	2.30	14.66	6.80	0.90
28. Condon.....	Pasadena.....	143	34.20	69.11	2.50	21.00	6.73	0.66
29. Condon.....	Pasadena.....	150	24.00	70.30	1.31	23.55	3.62	1.22
Average Condon.....		146	29.10	69.70	1.91	22.28	5.17	0.94
30. Dickey.....	Hollywood.....	363	30.00	60.50	2.20	27.11	8.76	1.43
31. Dickey*.....	Nordhoff.....	560	24.55	81.10	2.01	11.81	3.75	1.33
32. Dickinson.....	Puente.....	254	29.99	72.04	1.56	20.36	4.69	1.35
33. Fowler.....	Pasadena.....	132	35.80	70.33	1.60	21.20	5.61	1.26
34. Fuerte.....	Yorba Linda.....	315	25.71	66.30	1.42	25.32	5.68	1.28
35. Fuerte.....	Yorba Linda.....	566	26.14	68.32	1.36	24.23	4.82	1.27
Average Fuerte.....		440	25.92	67.31	1.39	24.77	5.25	1.28
36. Fuerte*.....	Yorba Linda.....	254	23.62	80.88	1.04	11.61	5.53	0.94
37. Fuerte.....	Altadena.....	270	26.48	65.26	1.40	28.68	3.22	1.44
38. Fuerte.....	Altadena.....	256	28.71	65.67	1.51	26.60	4.62	1.60
Average Fuerte.....		263	27.59	65.46	1.46	27.64	3.92	1.52
39. Ganter.....	Whittier.....	205	16.60	63.86	2.25	25.60	6.58	1.71
40. Ganter*.....	Whittier.....	197	26.80	77.87	2.13	16.48	2.48	1.04
41. Harman*.....	Sherman.....	127	35.50	75.17	1.69	15.25	7.00	0.89
42. Harman*.....	Sherman.....	136	37.90	76.09	1.24	15.34	6.65	0.68
43. Harman*.....	Sherman.....	170	37.40	75.42	1.47	16.26	5.86	0.99
Average Harman*.....		144	36.93	75.56	1.47	15.62	6.50	0.85
44. Harman.....	Sherman.....	235	46.38	71.58	2.50	19.33	5.32	1.27
45. Harman.....	Sherman.....	263	34.70	74.70	1.60	18.30	4.60	0.80
46. Harman.....	Sherman.....	233	33.50	72.05	1.43	21.51	4.24	0.77
47. Harman.....	Sherman.....	215	34.90	73.44	1.14	18.68	5.17	1.57
48. Harman.....	Sherman.....	192	28.00	72.75	1.16	19.18	5.86	1.05
Average Harman mature.....		227	41.61	72.90	1.57	19.40	5.03	1.10

* Immature.

TABLE 1.—(Continued)

Variety	Locality	Weight of fruit grams	Refuse per cent	Edible Portion				
				Water per cent	Protein per cent	Fat per cent	Carbo- hydrates per cent	Ash per cent
49. I. X. L.*.....	Duarte.....	705	31.60	84.27	2.12	7.50	4.70	1.41
50. I. X. L.....	Duarte.....	800	23.00	78.12	2.17	13.47	4.74	1.50
51. Kist.....	Yorba Linda.....	456	31.35	76.84	1.51	12.16	8.13	1.36
52. Kist.....	Yorba Linda.....	478	28.20	74.71	2.41	14.92	6.49	1.47
Average Kist.....		467	29.77	75.78	1.96	13.54	7.31	1.41
53. Lamat.....	Duarte.....	332	30.42	77.32	1.42	14.29	5.57	1.40
54. Lambert.....	Hollywood.....	285	33.40	76.52	2.86	14.31	5.40	0.91
55. Lyon.....	Hollywood.....	453		75.78	2.48	16.31	4.38	1.05
56. Lyon.....	La Habra.....	453	26.50	74.80	2.76	15.58	6.01	0.85
57. Mattern.....	Unknown.....	92	44.00	61.55	2.20	25.70	8.94	1.61
58. Mayapan.....	Duarte.....	397	37.28	68.33	1.77	22.83	5.59	1.48
59. Mayapan.....	Duarte.....	449	28.06	70.26	2.25	21.80	4.13	1.56
Average Mayapan.....		423	32.67	69.29	2.01	22.32	2.86	1.52
60. Meserve.....	Puente.....	331	40.00	74.66	2.19	17.01	4.78	1.36
61. Miller.....	Hollywood.....	184	35.80	66.60	3.70	23.70	4.51	1.49
62. Miller.....	Pasadena.....	275	40.00	63.68	3.36	27.45	4.18	1.33
63. Monrovia.....	Altadena.....	166	37.00	64.18	2.09	25.34	6.73	1.66
64. Nimlich.....	Duarte.....	860	24.42	78.55	1.53	13.93	4.83	1.16
65. Northrup.....	Santa Ana.....	164	34.70	66.31	2.36	23.00	7.12	1.21
66. Pankay.....	Duarte.....	385	41.30	73.15	1.58	14.56	9.10	1.61
67. Pankay.....	Duarte.....	310	46.12	71.03	1.64	16.30	9.61	1.42
Average Pankay.....		347	43.76	72.09	1.61	15.43	9.36	1.51
68. Pomona.....	Sacramento.....	79	43.00	61.84	3.50	25.36	7.36	1.94
69. Popenoe 101.....	Altadena.....	327	23.82	58.71	2.39	31.59	5.65	1.66
70. Popenoe 101.....	Altadena.....	375	29.34	60.78	1.82	29.78	5.92	1.70
Average Popenoe 101.....		346	26.58	59.74	1.65	30.68	5.78	1.68
71. Puebla*.....	Altadena.....	168	34.00	80.59	1.76	11.32	5.22	1.11
72. Puebla.....	Altadena.....	280	27.50	69.47	1.66	20.94	6.65	1.28
73. Puebla.....	Altadena.....	158	36.00	67.53	1.83	26.14	3.16	1.34
Average Puebla mature.....		219	31.75	68.50	1.74	23.54	4.91	1.31
74. Purdy.....	Whittier.....	168	32.10	60.28	1.14	31.60	5.49	1.49
75. Purple Prolific.....	Orange.....	219	45.90	69.30	1.67	19.93	8.27	0.83
76. Queen.....	Unknown.....	663	29.15	73.80	2.21	16.35	6.01	1.63
77. Queretaro.....	Yorba Linda.....	217	37.80	71.46	2.85	17.45	6.79	1.45
78. Queretaro.....	Altadena.....	164	36.60	71.46	2.34	18.21	6.56	1.43
79. Rhoad.....	Orange.....	395	37.00	82.46	1.19	9.78	6.03	0.54
80. Rita*.....	Orange.....	321	42.68	71.05	1.57	14.13	12.25	1.00
81. Royal.....	Hollywood.....	600	26.33	76.34	1.39	15.61	5.97	0.69
82. Royal Purple.....	San Diego.....	200	26.00	72.96	1.72	19.39	4.84	1.09
83. Senor.....	Orange.....	528	21.00	74.70	1.69	17.03	5.45	1.13
84. Sharpless*.....	Santa Ana.....	471	21.23	76.73	2.15	15.73	3.69	1.70
85. Sharpless*.....	Santa Ana.....	555	22.50	75.33	3.06	15.87	4.52	1.22
Average Sharpless*.....		513	21.86	76.03	2.60	15.80	4.11	1.16
86. Sharpless.....	Santa Ana.....	594	23.10	71.21	1.70	20.54	5.43	1.12
87. Sharpless.....	Santa Ana.....	536	24.10	72.63	1.27	18.77	6.39	0.94
Average Sharpless.....		565	23.65	71.92	1.48	19.65	5.91	1.03
88. Sinaloa.....	Whittier.....	616	23.40	73.55	2.67	16.43	5.57	1.78
89. Spinks.....	Duarte.....	388	31.50	76.22	1.50	14.83	5.96	1.49
90. Spinks.....	Duarte.....	877	20.30	75.72	2.10	16.01	4.74	1.43
Average Spinks.....		633	25.90	75.97	1.80	15.42	5.35	1.46
91. Surprise.....	Hollywood.....	538	26.00	82.51	1.90	9.96	4.86	0.77
92. Taft.....	Orange.....	626	29.00	72.53	2.66	18.54	5.16	1.11
93. Taft*.....	Orange.....	417	25.00	76.11	2.30	14.67	6.00	0.92
94. Taft*.....	Orange.....	296	27.00	77.25	3.44	12.59	4.91	1.81
Average Taft*.....		356	26.00	76.68	2.87	13.63	5.45	1.37

* Immature.

TABLE 1.—(Continued)

Variety	Locality	Weight of fruit grams	Refuse per cent	Edible Portion				
				Water per cent	Protein per cent	Fat per cent	Carbo- hydrates per cent	Ash per cent
95. Topa Topa.....	Nordhoff.....	123	27.70	75.00	2.30	15.48	6.14	1.08
96. Trapp.....	Florida.....	638	28.50	78.66	1.61	9.80	9.08	0.85
97. Ultimate.....	Orange.....	277	37.40	75.01	1.57	14.51	4.88	1.03
98. Walker.....	Sherman.....	174	37.10	68.66	3.15	18.71	7.55	1.93
99. Wagner.....	Hollywood.....	259	47.00	74.84	2.77	16.03	5.05	1.30
100. Dr. Weldon.....	Duarte.....	450	41.00	63.75	2.57	24.29	7.79	1.60
101. W. I. G.....	Altadena.....	123	28.50	60.00	2.63	26.73	9.08	1.56
102. White.....	Santa Barbara....	162	35.00	77.06	1.74	14.64	5.49	1.07

	No. of Analyses	Weight of fruit grams	Refuse per cent	Water per cent	Protein per cent	Fat per cent	Carbo- hydrates per cent	Ash per cent
Maximum.....	83	928	47.00	82.31	4.39	31.60	10.00	1.94
Minimum.....	83	79	13.60	58.71	1.14	9.78	2.59	0.54
Average.....	83	347	32.11	70.56	2.10	20.06	5.95	1.32

Mature California grown fruits only are included in above tabulation.

PARTIAL ANALYSES

Variety	Locality	Weight of fruit grams	Refuse per cent	Water per cent	Fat per cent
1. Atlixco.....	Yorba Linda.....	352	26.52	63.70	28.80
2. Atlixco.....	Yorba Linda.....	532	26.86	63.10	26.90
Average Atlixco.....		442	26.69	63.40	27.95
3. Goldie.....	San Diego.....	165	35.50	56.50	26.67
4. Knight.....	Yorba Linda.....	570	26.95	71.03	23.31
5. Linda.....	Unknown.....	890	20.23	82.66	7.48
6. Snell.....	Sierra Madre.....	306	29.00	55.00	32.70
7. Tahiti.....	San Diego.....	256	19.50	50.60	23.20
8. Whittier.....	Whittier.....	687	23.00	75.20	21.20

The carbohydrate content of the avocado is low as compared with this constituent in fresh fruits. The average for the 83 mature varieties is 5.95 per cent, with a maximum of 10 per cent and a minimum of 2.59 per cent.

The figures quoted in the table for carbohydrates include crude fiber which was not determined in every case. Analyses of a number of samples have shown, however, that this ingredient would average about 1.5 per cent, which compares very favorably with the content of crude fiber in other fresh fruits.

It is of decided interest to note that the percentage of mineral matter in the avocado is much higher than that recorded for any other fresh fruit. The minimum 0.54 per cent, reported for the Rhoad variety, equals approximately the average for most of our fresh fruits, while the average for the avocado, 1.32 per cent, shows that it contains twice as much mineral matter as that yielded by any other fruit.

The following analysis of the ash of the avocado shows that, like other fruit, the avocado yields an excess of the base-forming elements:

Silica	0.50
Phosphoric acid	17.40
Lime	4.72
Magnesia	5.30
Iron	1.51
Aluminum	2.58
Manganese	Trace
Sulfuric Acid	11.24
Chlorin	14.36
Potash	26.23
Soda	18.55
	101.89
Oxygen equivalent to chlorin	2.09
	99.80

Nearly one-half of the ash consists of soda and potash, the latter predominating. Magnesia and lime occur in comparatively small amounts, about 5 per cent each; the phosphoric acid averaging about 17.5 per cent, with 1.5 per cent of iron.

The foregoing discussion clearly indicates that so far as protein and ash in fresh fruits are concerned, the avocado stands at the head of the list, and, with reference to the carbohydrates, contains on an average fully 50 per cent of that found in many fresh fruits. These facts alone would warrant due consideration of the value of the avocado as a fresh fruit.

The chief value of the avocado as food, however, is due to its high content of fat. This varies, as shown by the analyses, from a minimum of 9.78 per cent to a maximum of 31.6 per cent, with an average of 20.6 per cent.

Reviewing the analytical data, it will be seen that 15 varieties show more than 25 per cent fat and 14 other varieties an excess of 20 per cent. The only fruit comparable with the avocado in this respect is the olive. In this connection, it is of interest to note the comparison as shown in the following table, of the fat percentages of the edible portion of ten varieties of the avocado containing 25 per cent or more of fat, with ten varieties of the olive.

TABLE 2.—SHOWING PERCENTAGE OF FAT OR OIL IN THE AVACADO AND OLIVE

AVOCADO—EDIBLE PORTION				OLIVE—EDIBLE PORTION	
	<i>Original Material</i>	<i>Water-Free</i>		<i>Original Material</i>	
Variety	Water per ct.	Fat per ct.	Fat per ct.	Variety	Oil per ct.
Purdy	60.28	31.60	79.70	Corregiolo	27.68
Popenoe	59.74	30.68	76.20	Nigerina	26.16
Chappelow	60.94	29.10	74.40	Nevadillo Blanco	22.92
Fuerte	65.26	28.68	82.50	Mission	22.51
Miller	63.68	27.45	75.60	Rubra	22.01
Dickey	60.50	27.11	68.70	Pendulina	21.36
Azusa	62.69	26.44	70.90	Redding Picholine....	20.83
Carmen	63.39	26.38	72.10	Macrocarpa	20.41
Ganter	63.86	25.60	70.80	Manzanillo	19.73
Blake	65.76	25.50	74.50	Columbella	19.54

The figures in table 2 indicate that the avocado ranks higher in fat or oil than the average or commonly used olive. The olive also has the disadvantage of requiring special treatment before it is ready for consumption and should really rank as a processed fruit rather than a fresh one. The data in the table show that, when considering the dry matter only, the Purdy has the highest per centage of fat. In the original condition, the Blake and the Chappelow differ in fat by nearly 4 per cent, which difference is practically eliminated when comparison is made on a water-free basis, which is the only true way to compare the nutritive value of fruits.

CALORIC VALUE

While it is true that the real value of any food is not always represented by the heat units or calories, at the same time, the total food value is so indicated. This difference between the real food value and the total food value is not always properly understood. For instance, the energy value of a pound of sugar is 1820 calories, while the corresponding value for lean meat is less than 1000 calories. Yet we would hardly say that the real value of a pound of sugar was 1.8 times that of a pound of lean meat, if the question of growth were under consideration. When, however, the matter of energy is being discussed the case is entirely different, and the value of a food as a source of energy varies directly with its caloric value.

The energy values of the edible portion of the commonly used fresh fruits are low, ranging from a minimum of 175 calories to a possible maximum of 400 calories per pound.

An inspection of table 3 shows that the avocado has a far higher value in this respect, the average for twenty varieties, being 1056 per pound, or more than twice the maximum (400 calories) noted for

other fresh fruits. The minimum, 783 calories, approaches very closely to this figure. The maximum, 1376 calories per pound, corresponds to that noted for some varieties of *dried* fruits. It is practically 75 per cent of the fuel value of the cereals and far in excess of the fuel value of lean meat.

TABLE 3.—SHOWING THE ENERGY VALUE OF THE AVOCADO

No. and variety	Energy value per pound calories	No. and variety	Energy value per pound calories
1. Azusa	1,235	12. Mayapan	992
2. Blake	1,083	13. Miller	1,159
3. Blakeman	783	14. Northrup	1,101
4. Cabnal	1,100	15. Pomona	1,223
5. Chappelow	1,184	16. Popenoe	1,376
6. Dickey	1,293	17. Puebla	1,026
7. Dickinson	958	18. Queen	812
8. Fuerte	1,187	19. Sharpless	928
9. Ganter	1,195	20. Sinaloa	814
10. Harman	904		
11. Lyon	785	Average	1,056

DIGESTIBILITY

Digestion experiments conducted by Mattill¹² have shown that the digestion coefficient for avocado fat for man is 93.8, which is identical with the average obtained by Dr. Langworthy and Holmes in connection with the digestibility of butter fat by man. In other words, the digestibility of avocado fat is on a par with butter fat.

There have, however, been no metabolism experiments carried on in connection with the protein and carbohydrates of the avocado, yet it is only fair to assume that this fruit is as easily digested as many others whose coefficients have been determined. Such data clearly prove that the fruits are quite thoroughly digested. The availability of the fats and mineral matter are fully equal to that obtained for the mixed diet; and the digestion coefficients of the carbohydrates compare very favorably with the corresponding figures for other foods, but the availability of the protein is appreciably lower.

VITAMINS

Dr. Santos¹³ has shown that the avocado is an excellent source of vitamin B or the antineuritic vitamin. He found that one-half gram of the avocado as a daily supplement to the standard vitamin B free diet, caused a recovery in the weight of rats which had been declining because of lack of this accessory food factor.

Studies are now in progress by the Nutrition Division for the purpose of ascertaining the content of vitamin C in the avocado. This

¹² California Avocado Association, Annual Report, 1916.

¹³ Amer. Jour. Physiol. LIX, 1922, p. 310.

fruit is eaten raw and therefore if it proves to be high in vitamin C, its nutritional value will be greatly enhanced. There are many fruits and foods which contain appreciable amounts of vitamin C in the raw state but which have to be processed or cooked before ready for consumption, resulting in a great lowering of the potency of the antiscorbutic vitamin. In some instances, cooking or processing is entirely destructive to this accessory food factor.

DIETETIC VALUE

The dietetic value of fruit, aside from the actual nutrients which it contains, lies in its succulency, its minerals, its vitamins, and its organic acids. If gauged by its nutritive value alone, fruit would seem to be an expensive form of nourishment, but when its hygienic qualities are considered its money value to the consumer is difficult to estimate. Some fruits carry more nourishment with their hygienic properties than others. Some contain minerals which are more valuable to the system or less commonly distributed than others. Again, there are the citrus fruits which are rich in vitamin C. Therefore, while there are general properties which are common to all fruits, each has special properties which justify individual consideration.

While the special dietetic value of a food can not always be forecast by the chemical analysis, it is certainly permissible to suggest the possibilities which are indicated by the results of such investigation. It is always necessary that such theory be confirmed by clinical experience.

Judging from its composition, the avocado should perhaps prove to have laxative qualities of a peculiar or individual type, possessing as it does the combination of the usual "fruit principles," and that of fat or oil. The laxative properties of most fruits depend upon the stimulating effects of the fiber upon the wall of the intestine and partly upon the organic acids and minerals. Oil has a tendency to soothe and to lubricate the intestine even while it acts as a mild laxative. The avocado is a natural combination of these two types of foods—as if fruit and olive oil had been chemically combined by nature. Whether or not there is any special advantage in this natural combination over that made by a proper selection of foods remains to be proved. There are no clinical data on the subject, but future experimental work may furnish some interesting results.

The fact that the native Cubans prefer this fruit to any other of their abundant supply may be due to its flavor alone, but it is more than likely that the preference has a deeper foundation and that it is the result of generations of experience or knowledge of its beneficial effects.

